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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 21 JULY, 1922 NO. 1

MANUFACTURE OF CERTAIN DRUGS FOR THE TREATMENT OF LEPROSY [1]

By GRANVILLE A. PERKINS

Chemist, Bureau of Science, Manila

ONE PLATE

The chemical investigation of leprosy drugs by the Bureau of Science [2] has been continued since Brill's latest paper, especially since May, 1920, when the work was placed in the hands of the Committee on Leprosy Investigation, a joint committee of the Philippine Health Service, the University of the Philippines, and the Bureau of Science. Since that time the Bureau of Science has prepared a number of drugs, which were used experimentally at San Lazaro Hospital and Culion Leper Colony. Practically all of these have been found to be beneficial, in varying degrees. The report of this work from the medical point of view, including the methods of administration and observed effects, will be published by the committee. The present paper is written from the chemist's standpoint, and takes up the preparation and chemical composition of the drugs used.

The treatment of leprosy in recent years has tended away from the old methods of oral administration and inunction toward the injection method, both intramuscular and intravenous. Although the manner of application has changed, the basis of the drugs most used has remained the same for centuries, chaulmoogra oil. Rock[3] has found an old Buddhist account of "a Burmese king voluntarily exiled for leprosy about 1,000 years ago who cured himself with the [chaulmoogra] oil, and likewise effected the cure of a beautiful young woman whom he afterwards married, founding a dynasty."

---

[1] Received for publication January 28, 1922.

[2] Brill, H. C., Hydnocarpus venenata Gaertner; false chaulmoogra, Philip. Journ. Sci. § A 11 (1916) 75; A chemical investigation of the seeds of Pangium edule and of Hydnocarpus alcalae, ibid. § A 12 (1917) 37; Brill, H. C., and Williams, R. R., The use of chaulmoogra oil as a specific for leprosy, ibid. § A 12 (1917) 207.

CHAULMOOGRA OIL

This oil, according to the present official definition, is the fixed oil from the seeds of *Taraktogenos kurzii*, a large tree which grows in the Assam Valley and Chittagong Hill Tracts, India. Similar oils, not correctly called chaulmoogra but perhaps quite as effective, are obtained from *Hydnocarpus wightiana*,[4] growing on the Malabar coast; *H. venenata*,[2] [4] Ceylon, Deccan, and Burma; *H. castanea*,[4] Burma; *H. anthelmintica*,[4] Siam and French Indo-China; *Asteriostigma macrocarpa*,[4] Travancore; *H. alcalae*,[2] Albay, P. I.; *H. hutchinsonii*,[5] Mindanao, P. I.; *H. subfalcata*,[5] Zambales, P. I.; and *Onchoba echinata*,[6] Sierra Leone. *Pangium edule*,[2] found in the southern Philippines and neighboring islands, gives an oil somewhat similar in composition, but the oil from *Gynocardia odorata*, which was long confused with chaulmoogra, is totally different, from both the chemical[7] and the bacteriological[8] standpoints.

Chaulmoogra oil, like most fixed vegetable oils, is composed nearly entirely of fatty acids combined with glycerine. The principal fatty acids in the oil from *Taraktogenos kurzii* and a few closely related species, most of which are mentioned above, are of a peculiar type known as the chaulmoogric acid series.

---

[3] Rock, J. F., U. S. Dept. Agr. Weekly News Letter 9 (1921) 1.

[4] Muir, E., Handbook on Leprosy. Orisa Mission Press, Cuttack, India (1921) 39.

[5] A chemical investigation of these oils will be reported in the near future.

[6] Goulding and Akers, Chem. Soc. Proc. 29 (1913) 197.

[7] Power, F. B., and Barrowcliff, M., Journ. Chem. Soc. 87 (1905) 897. The sample of "*Gynocardia odorata*" seeds obtained by Brill and Williams, Philip. Journ. Sci. § A 12 (1917) 211, from the Department of Agriculture at Assam was evidently *Taraktogenos* or *Hydnocarpus*. Since the external appearance of all these seeds is somewhat similar, it is important to note the easy distinction pointed out in Muir's Handbook, p. 39. The radical of the *Gynocardia* seed is lateral, while that of the *Taraktogenos* and *Hydnocarpus* is terminal.

[8] Unpublished work with tubercle bacilli by Dr. O. Schöbl, Bureau of Science.

The acids of this series are found nowhere else in nature, nor have they been synthesized in the laboratory. Expressed in terms of molecular structure, the distinguishing characteristic of these acids is that they contain a closed ring of five carbon atoms. All other known fatty acids have their carbon atoms in the form of an open chain. Due to this structural peculiarity, the acids of the chaulmoogric series have the power of optical rotation, and may be detected by the polariscope.

The nomenclature of the peculiar acids of chaulmoogra oil was initiated in 1879 by Moss,[9] who supposed chaulmoogra oil to be derived from *Gynocardia odorata*. He gave the name "gynocardic acid" to a crystalline preparation melting at about 29° C. This was later shown to be mixture, by Power and his collaborators,[10] who definitely isolated from chaulmoogra oil the acids which they named chaulmoogric and hydnocarpic. They considered the glyceryl esters of these acids, together with some palmitic, to be the chief constituents of chaulmoogra oil.

The fact that some *Hydnocarpus* oils are very similar to *Taraktogenos* oil has led to the claim that these may be legitimately sold as chaulmoogra oil. If the word chaulmoogra is to be defined by its original native meaning, this claim can hardly be denied; but the modern practice of standardizing medical terms necessitates the restriction of the word to *Taraktogenos kurzii*. The question of the medicinal value of the various *Hydnocarpus* oils must be decided on their own merits. Chemical investigation has shown that they are very similar to chaulmoogra oil and contain at least two of the same peculiar fatty acids which have been proved to be effective in the treatment of leprosy. The optical rotatory power is the best present single analytical criterion of this property, though the results of McDonald and Dean [11] indicate that the iodine absorption value is also important. The writer expects to publish an analytical study of various *Hydnocarpus* oils in the near future.

The clinical results on record are not confined to chaulmoogra oil; in fact, experts in India have in recent years preferred *Hydnocarpus wightiana* oil. This is encouraging to us in the Philippines, as we have no indigenous *Taraktogenos kurzii*, but

[9] Moss, Year-book of Pharmacy (1879) 523–533.

[10] Power and Gornall, Journ. Chem. Soc. **85** (1904) 838, 851; Power and Less, ibid. **87** (1905) 349; Power and Barrowcliff, ibid. 884; Barrowcliff and Power, F. B., Am. Journ. Pharm. **87** (1915) 493.

[11] McDonald, J. T., and Dean, A. L., Journ. Am. Med. Assoc. **76** (1921) 1472.

we have *Taraktogenos heterophylla* and a commercial supply of *Hydnocarpus.*

USE OF THE OIL IN THE TREATMENT OF LEPROSY

The use of chaulmoogra oil orally and externally in leprosy has so long been favored by the medical profession that it is not necessary to dwell on the detailed reports of beneficial results. Although its action has been so slow and uncertain that some physicians have had doubts of its efficacy, yet the consensus among them has been that chaulmoogra has a definite beneficial effect in leprosy, not produced by any other oil except perhaps the *Hydnocarpus* oils. This fact at once points to some specific effect of the peculiar fatty acids of chaulmoogra on the bacillus of leprosy. A remarkable confirmation of this idea is seen in the recent experiments of Walker and Sweeney,[12] who have demonstrated that the sodium salts of the chaulmoogra fatty acids are about one hundred times more bactericidal to acid-fast bacteria than is phenol. They further found that sodium salts of other fatty acids are practically inactive, and also that the action of chaulmoogra acids on acid-fast bacteria does not extend to other common pathogenic bacteria. They conclude (p. 259) that "any therapeutic action which chaulmoogra oil may have in leprosy is due to its direct antiseptic and bactericidal action on B. leprae." As to the "active principle" of the oil they decide that "the bactericidal activity is a function of the chaulmoogric acid series." To explain the specificity against acid-fast bacilli they propose the hypothesis that "these fat-elaborating bacilli attempt to utilize the chaulmoogric acids to build up their fatty capsules, and that these cyclic fatty acids contain a group or an arrangement of atoms which is toxic for the bacterial cell." Lastly, they conclude that this toxicity is unique with the chaulmoogric acid series, and not shown by the ordinary fatty acids; for example, those found in cod-liver oil.

While these four conclusions of Walker and Sweeney are based on extensive and careful experiments, they do not agree with opinions that have been based on clinical evidence. Practical experience in treating large numbers of lepers has led to various theories, of which those of Mercado and of Rogers, respectively, will be mentioned as examples.

Mercado explains the action of chaulmoogra oil as follows:[13]

---

[12] Walker and Sweeney, Journ. Inf. Dis. 26 (1920) 238.

[13] Mercado, E., Leprosy in the Philippines and its Treatment. Manila (1915) 55.

> The organism repels the bacillary invasion due to the concurrence of a larger number of defensive elements as the leucocytes which possess phagocytic powers to destroy and exterminate the bacilli. In order that the organism may acquire a greater number of leucocytes for its defense, a stimulant or reactive is needed to provoke leucocytic hypergenesis, such as we are able to acquire from the presence and action of a fatty substance as the oil of chaulmoogra which also contains gynocardic acid, an alterative, acting upon the system as all other organic acids.

Other leprologists assume a similar, indirect effect.

Rogers, on the other hand, believes the effect to be direct, but not confined to chaulmoogra oil. He states[14] that there is nothing absolutely specific against leprosy in the products of chaulmoogra oil and—

> that the sodium salts of the unsaturated fatty acids of these two oils [chaulmoogra and cod-liver oils] act in some way on the coating of the acid-fast bacilli, that of tuberculosis having been shown to contain palmitic and other unsaturated fatty acids. During the past year [1918] sodium morrhuate has been used with very promising results in tuberculosis by several careful observers to whom I have supplied it, and morphological changes have been noted in the tubercle bacilli in the sputum. A wide field of investigation has thus been opened out, as it appears to be possible that the organisms of other chronic diseases, including that of syphilis, might possibly be broken up in the system by similar methods.

By "sodium morrhuate" Rogers means the sodium salts of the principal fatty acids of cod-liver oil. He has later used successfully also ethyl esters made from cod-liver oil and sodium salts from soya-bean oil.[15]

The point which seems important to Rogers is that chaulmoogric and hydnocarpic acids are unsaturated; that is, they have the power of combining with iodine, bromine, hydrogen, and oxygen by direct addition of these elements; whereas a saturated fatty acid, like palmitic, for example, is comparatively inert chemically. Unsaturation is also a property of the acids in cod-liver, soya-bean, and many other oils.

While Rogers's theory is not supported by such definite experimental evidence as that of Walker, yet the fact remains that sodium morrhuate has an effect in leprosy and tuberculosis very similar to that of the chaulmoogra preparations. Walker's conclusions are therefore not strictly correct, but they at least furnish a scientific starting point toward the solution of the problem of leprosy treatment.

[14] Rogers, L., Brit. Med. Journ. 1 (1919) 147.

[15] Rogers, L., Ind. Med. Gaz. 55 (1920) 127.

METHODS OF TREATMENT BASED ON CHAULMOOGRA AND OTHER OILS

Until recently chaulmoogra oil was used principally in the crude form and was administered chiefly by mouth. The disadvantages of this method were that the nauseating properties of the oil seriously limited its use, and the action, even of large amounts, was slow. To obviate these difficulties, a number of other methods of administration were tried, in which the first real success was obtained by Mercado[13] who used the formula (p. 54):

"Camphorated oil 10 per cent	aa 60 c.c.
Chaulmoogra oil, pure and sterile	
Resorcine	4 grams.
Purified ether	2.50 c.c.

Misc. Sig.: For intramuscular injection."

The camphorated oil is added because it "on account of its oils, helps the oil of chaulmoogra and besides that, it acts independently upon the heart and is at the same time, a recognized therapeutical agent which constantly increases phagocytic activity." Heiser states[16] that camphor and ether were suggested by the Merck Co., to assist in the absorption of the chaulmoogra oil. The resorcine was used for its antiseptic properties.

The intramuscular method is generally conceded as an advance on the oral administration of chaulmoogra oil, both because it avoids the nauseating effect and because it produces more-rapid results. The Mercado mixture has been found less irritating and is more easily absorbed than the pure oil injected in the same manner, although the pure oil, carefully prepared, is still injected intramuscularly in the asylums of Japan, where it is preferred on account of its more-concentrated form.

While the pure oil can be used intramuscularly, the crude commercial oil ordinarily sold is unsuited for such use, even though applied in the form of the Mercado mixture. A widespread idea that the crude oil is more efficacious has seriously interfered with the intramuscular treatment of leprosy. Heiser states:[17]

> Experience with chaulmoogra oil at San Lazaro Hospital, when administered by mouth, has shown that the crude oil is much more efficacious than the refined product. When used hypodermically, there is apparently no difference whether the crude or the refined oil is used, but accurate data with regard to this point are not yet available.

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[16] U. S. Pub. Health Rept. 29 (1914) 2765.

[17] Am. Journ. Trop. Dis. 2 (1914) 324.

The committee has made experiments using Mercado mixture prepared from chaulmoogra oil refined at the Bureau of Science, and from a high-grade oil made by Shiongi & Co., Osaka, Japan, which is either pressed from carefully selected seeds or else refined. In both cases it was found that the irritation was negligible as compared to that produced by the mixture made from ordinary commercial chaulmoogra oil. The free fatty acid was found to be one of the very irritating constituents of the crude oil. The fact that free fatty acid is more easily digested than neutral oil probably explains the superiority of the crude oil for oral administration.

Using the Mercado mixture as a standard for comparison, the committee has conducted experiments with seven newer preparations, all of which are designed for more-rapid absorption than occurs with the Mercado mixture. These are: Chaulmoogra ethyl esters, Muir's E. C. C. O., sodium gynocardate A, sodium gynocardate S, chaulmoogra emulsion, sodium morrhuate, and cod-liver ethyl esters. The composition and chemistry of each of these will be considered in turn.

CHAULMOOGRA ETHYL ESTERS [18]

The mixed ethyl esters of the fatty acids of chaulmoogra oil came on the market several years ago as "antileprol"[19] made by the Bayer Co. This was found by Mercado[20] to have no better effect than the oil when taken orally. Tests on two patients were made intramuscularly without results, but in these cases only 2 per cent and 5 per cent solutions were used.

The ethyl ester treatment has been used very successfully by Dean and his collaborators at Honolulu,[21] and the committee has obtained excellent results with it at San Lazaro Hospital.

The ethyl esters seem to be more easily absorbed than the oil, perhaps because they form a more-mobile liquid, which is easily emulsified. They have even been used intravenously by Muir.[22]

The method usually employed in making these ethyl esters seems to be to prepare the soap, then the fatty acids, and finally to esterify with the help of dry hydrochloric acid gas. The writer has found this method cumbersome on the large scale, and at present esterifies the oil directly, with the help of sulphuric acid.

---

[18] With the assistance of Mr. Ernesto Paras.

[19] Patents, D.R.P. 216,092, and B.P. 1984–1909, were granted for these ethyl esters, although Power had long before prepared them, and published accounts of his work.

[20] Op. cit. 43.

[21] McDonald and Dean, U. S. Pub. Health Rept. 35 (1920) 1959; Hollmann and Dean, Journ. Cutaneous Dis. 37: 367–373.

[22] Handbook on Leprosy. Orisa Mission Press, Cuttack, India (1921) 46.

Ten kilograms of crude chaulmoogra oil, 13 liters of 95 to 96 per cent alcohol, and 750 cubic centimeters of 66° Bé. commercial sulphuric acid are placed in a 26-liter stoneware acid carboy which has been fitted with a sheet iron steam jacket and a large glass reflux condenser. A slow current of low-pressure steam is allowed to enter at the top of the jacket, provision being made at the bottom for escape of the condensed steam. The contents of the carboy are thus boiled gently for twenty hours.

The reaction that slowly takes place is the well-known one of interchange of alkyl groups under the influence of a mineral acid (hydrogen ion) catalyst. The glyceryl radical in the glycerides of the oil changes place with the ethyl group in the alcohol, forming the desired ethyl esters and glycerol.

The reaction product is syphoned into a large glass carboy, washed with about an equal volume of water and then with dilute caustic soda, just sufficient soda being added to produce a permanently alkaline reaction to phenolphthalein. The resulting emulsion separates fairly well after a few hours, and the upper layer is heated in a steam kettle to dry it.

This dry ester mixture is then distilled at about 50 millimeters pressure in a still made from a 30-centimeter (12-inch) length of 15-centimeter (6-inch) iron pipe capped and fitted with a reducing coupling. Gas heating has been used, but we have obtained a more-rapid output by the use of an electric heater (see Plate 1) and an electrically heated still head of 5-centimeter (2-inch) pipe, 150 centimeters (5 feet) long. Rolls of iron-wire netting are placed in the still head to prevent foaming over, which is the troublesome feature of this distillation. The heater is made from 20-centimeter (8-inch) stovepipe 45 centimeters (18 inches) long and 40-centimeter (16-inch) stovepipe 52 centimeters (22 inches) long, the space between the two walls being filled with asbestos fiber. The heating units are of No. 20 chromel A wire, 500 watts each, one flat coil at the bottom, three coils around the 20-centimeter stovepipe, and one coil around the still head. A Crowell 2–D vacuum pump has sufficient capacity for two of these stills.

The ester is allowed to enter the still by means of a tube running through the still head, in portions of about 200 cubic centimeters, each portion being distilled before the next one is added. When properly adjusted the still delivers at the rate of 4 liters an hour. After about 50 liters have been distilled the still head is taken off and the accumulated pitch cleaned out from the body of the still. Solvents are not very effective, so the pitch is liquefied by heat and removed by mechanical means.

The distilled esters contain volatile impurities which were found to be irritating. They are therefore placed in a stoneware carboy and agitated vigorously by a current of steam for two hours. Sometimes we wash the esters again with alkali at this point, but as the free fatty acid is seldom more than 1 per cent this step is generally omitted. In either case the product is freed from the accompanying water in a separatory funnel, and then filtered. The clear, almost colorless, filtered esters are next placed in small bottles, loosely corked, and heated to 150° C. Each cork is then pushed down and paraffined. In this form the ester is ready for use.

The ethyl ester is used not only in the pure form but also mixed with 2 per cent iodine, which is the standard preparation used by McDonald and Dean. The iodine is added to the dry ester, in which it gradually dissolves, combining chemically.

We recover alcohol from the first washings mentioned above by neutralizing with lime, and fractionating through an iron pipe 240 by 15 centimeters (8 feet by 6 inches) filled with broken glass. The alkaline wash water is collected in a barrel and acidified to break the emulsion. A mixture of ester and fatty acid rises to the top, and is skimmed off for reësterification along with another batch of oil. About 5 per cent requires reësterification in this manner.

The theoretical yield of ethyl ester is 1.05 kilograms per kilogram of chaulmoogra oil. A small amount of the oil remains as glyceride, which, along with unknown impurities and decomposition products from the ethyl ester, account for the accumulation of tar in the still. The amount of glyceride is low, and the decomposition of ethyl ester is also very small if a good vacuum is maintained. Under average working conditions 50 kilograms of oil have been found to give 2 kilograms of residue in the still. Together with the usual mechanical losses in handling, this cuts down our working yield to 90 or 95 kilograms of finished ester per 100 kilograms of chaulmoogra oil.

COMPARISON OF HYDROCHLORIC ACID WITH SULPHURIC ACID AS CATALYST

Strong sulphuric acid has a tendency to form addition products with unsaturated compounds, and is known to react with chaulmoogra oil. In order to ascertain whether such undesirable action takes place under the conditions which we use for the esterification, experiments have been conducted comparing the sulphuric acid catalysis with that of hydrochloric acid, which does not have a similar combining power. The results of typical parallel experiments are shown in Table 1. In this case 1 liter of 95 per cent sulphuric acid instead of the usual 750 cubic centimeters of 93 per cent was employed as catalyst, and boiling was continued for forty-one hours to intensify the effect. The control experiment was done in the same manner, but instead of adding sulphuric acid dry hydrochloric acid gas was passed into the alcohol until it showed 5 per cent by titration. Thirteen liters of 96 per cent alcohol and 10 kilograms of oil were used in each experiment. The oil was presumably pure *Taraktogenos*, being guaranteed by the maker, P. K. Sen, of Chittagong.

TABLE 1.—*Comparison of hydrochloric acid with sulphuric acid as catalyst.*

	Chaulmoogra oil.	Ester washed with water.		Distilled ester.	
Catalyst	----------	HCl	H_2SO_4	HCl	H_2SO_4
Specific gravity 30/4° C.	0.947	----------	----------	0.890	0.891
Refractive index 30° C. D line	1.4767	1.4575	1.4570	1.4568	1.4566
Optical rotation, D, 100 mm	46.0	40	38	38.1	38.9
Iodine No., Hanus	102	93	94	97.5	97
Saponification No.	198	187	190	187	188
Acidity, as per cent oleic	13.8	4.4	2.1	1.38	0.51
Freezing point of fatty acids, °C	29	29	30	30	31
Specific rotatory power of fatty acids dissolved in xylene	47.7	46.8	47.3	45.5	45.5

The data given in Table 1 show that sulphuric acid, under the given conditions, does not appreciably change the chaulmoogra fatty acids. The figures for the rotation of the washed esters are approximate, as they were too dark for accurate determination. The optical rotation of the hydrochloric acid esters decreased somewhat upon distillation. This decrease has been noted to occur when distillation is delayed by accidental difficulty with the vacuum, which happened in this run. The same may be said of the occurrence of free fatty acids in the distilled product. They were produced during distillation and have no relation to the free fatty acids in the crude products, as these were washed thoroughly with alkali before distillation.

The iodine numbers of the esters and the rotatory powers of the fatty acids show clearly that the use of sulphuric acid as a catalyst is permissible, even on long boiling. Sulphuric acid has obvious economical advantages as compared with hydrochloric acid gas and reduces, by its hygroscopic action, the amount of free fatty acid in the crude esters.

MUIR'S E. C. C. O.

The preparation and use of this mixture is described in Muir's Handbook on Leprosy, page 43. It is composed of *Hydnocarpus wightiana* ethyl esters, 1 cubic centimeter; double distilled creosote, 1 cubic centimeter; camphor, 1 gram; olive oil, 2.5 cubic centimeters. The committee has recently placed a group of patients under treatment with this drug.

SODIUM GYNOCARDATE A

This is the derivative of chaulmoogra oil used for subcutaneous and intravenous injection since 1917 by Leonard Rogers.[23] Recently he has called it sodium hydnocarpate,[24] but as it is really a mixture containing a large amount of sodium chaulmoograte there seems to be no good reason for changing the name. The name "gynocardate" has always been applied to a similar mixture, while "hydnocarpate" applies to a definite chemical individual. To prepare this drug, chaulmoogra oil is saponified by boiling it in a steam kettle with about four parts of water, adding one-fifth part of caustic soda in small portions. The fatty acids, which solidify at about room temperature, are liberated by the addition of sulphuric acid, then dried, and dissolved in alcohol. The solution is cooled in a refrigerator, which causes the less-soluble acids, particularly chaulmoogric, to crystallize out.

Several fractions are crystallized out, and the least soluble is mixed with sufficient of the intermediate fractions to give a product melting at 48° C. This, after neutralization with caustic soda, is a duplication of Rogers's preparation, as closely as can be ascertained.

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[23] Rogers, L., Ind. Journ. Med. Res. 5 (1917) 277.

[24] Rogers, L., Ind. Med. Gaz. 54 (1919) 165.

Sodium gynocardate A is used in the form of 3 per cent sterilized solution, containing 0.5 per cent phenol, and 0.5 per cent sodium citrate to avoid clotting.

SODIUM GYNOCARDATE S

This preparation was made in the same manner as sodium gynocardate A, except that the total fatty acids instead of the crystallized acids were employed. As the preparation was found to be irritating, the committee soon decided to use in its place a similar solution (sodium gynocardate D) differing only in that the fatty acids have been purified by distillation in vacuum. The irritating substances are thus removed to a large extent.

CHAULMOOGRA EMULSION

About the time that Rogers was beginning the intravenous injection of chaulmoogra soap solutions, Vahram[25] was using a very fine emulsion of chaulmoogra oil in the same manner. A mixture of the oil with 20 parts by weight of acacia was desiccated to cause intimate union, and then mixed with 1,390 parts of water, forming a very dilute emulsion. This preparation is now on the market as "Collobiasis of Chaulmoogra," made by the Laboratoires Pharmaceutiques de Dausse, Paris. This "Collobiasis" has been used by the Committee on Leprosy Investigation for direct infiltration in the lesions and, to a smaller extent, intravenously. A similar chaulmoogra emulsion, prepared at the Bureau of Science, has also been used for infiltration.

SODIUM MORRHUATE

Cod-liver oil has not been used to any large extent in leprosy, but it has had wide application in the treatment of tuberculosis. It was probably for this reason that Rogers[26] chose cod-liver oil as a basis for a preparation similar to sodium gynocardate for use in tuberculosis. The new drug, which he named sodium morrhuate, has given good results in the treatment of this disease, and even better results in the treatment of leprosy.

The composition of cod-liver oil is very complex. It contains glyceryl esters of the common fatty acids, palmitic, stearic, and oleic, together with a number of characteristic fish-oil acids

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[25] Vahram, M., Progrès Médical (1916) 19. New Orleans Med. and Surg. Journ. 69: 230.

[26] Rogers, L., Ind. Med. Gaz. 53 (1918) 73.

(clupanodonic and others) which have not been so fully investigated.[27] These characteristic acids all have the property of unsaturation, which has been previously discussed in connection with chaulmoogra oil.

The sodium morrhuate used in the experiments of the Committee on Leprosy Investigation has been prepared by Rogers's method.[28]

This consists in making the sodium soap of cod-liver oil and extracting with ether to remove irritating substances. A 3 per cent solution has been used, principally by intravenous injection.

COD-LIVER OIL ETHYL ESTERS

This preparation has been recommended by Rogers [29] as being less irritating than chaulmoogra ethyl esters. The committee obtained the opposite result, probably because of differences in the methods of preparation. The addition of 2 per cent iodine, however, seems to destroy the irritating constituents, so this mixture is now being used by the committee.

CONCLUSION

In conclusion, the writer wishes to point out that the success recently attained in the treatment of leprosy and tuberculosis with drugs derived from certain oils is encouraging, not only in itself but also in the prospect for improvement that it promises. If Walker's idea of the absorption of toxic fatty substances by acid-fast bacilli is correct, it should be easy to make in the laboratory a much more effective drug by properly combining a toxic element like arsenic or antimony with a fatty acid. If Rogers's idea of the efficacy of unsaturation in general proves to be correct, oils may be used that are much more unsaturated than chaulmoogra oil. The conclusions as to the value of the various drugs described above must of course be deferred to the medical report of the committee, but it may be stated that the intramuscular ethyl ester treatment has been decided upon for the main routine treatment at Culion Leper Colony. About 200 liters (40,000 doses) per month are now being manufactured at the Bureau of Science for that purpose.

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[27] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats & Waxes. London 2 (1914) 424.

[28] Rogers, L., Brit. Med. Journ. 2 (1919) 426; Ind. Journ. Med. Res., Special number, 7 (1919) 238.

[29] Rogers, L., Ind. Med. Gaz. 55 (1920) 127.

SUMMARY

1. Recent developments in leprosy treatment are discussed from a chemist's viewpoint.

2. The manufacture of chaulmoogra ethyl esters is described in detail.

3. The preparation of six other drugs, mostly following the procedure of other investigators, is described, these being the other medicines chosen by the Committee on Leprosy Investigation for experimental treatment.

ILLUSTRATION

PLATE 1

A portion of the Bureau of Science leprosy-drug plant, showing vacuum distillation of ethyl ester.

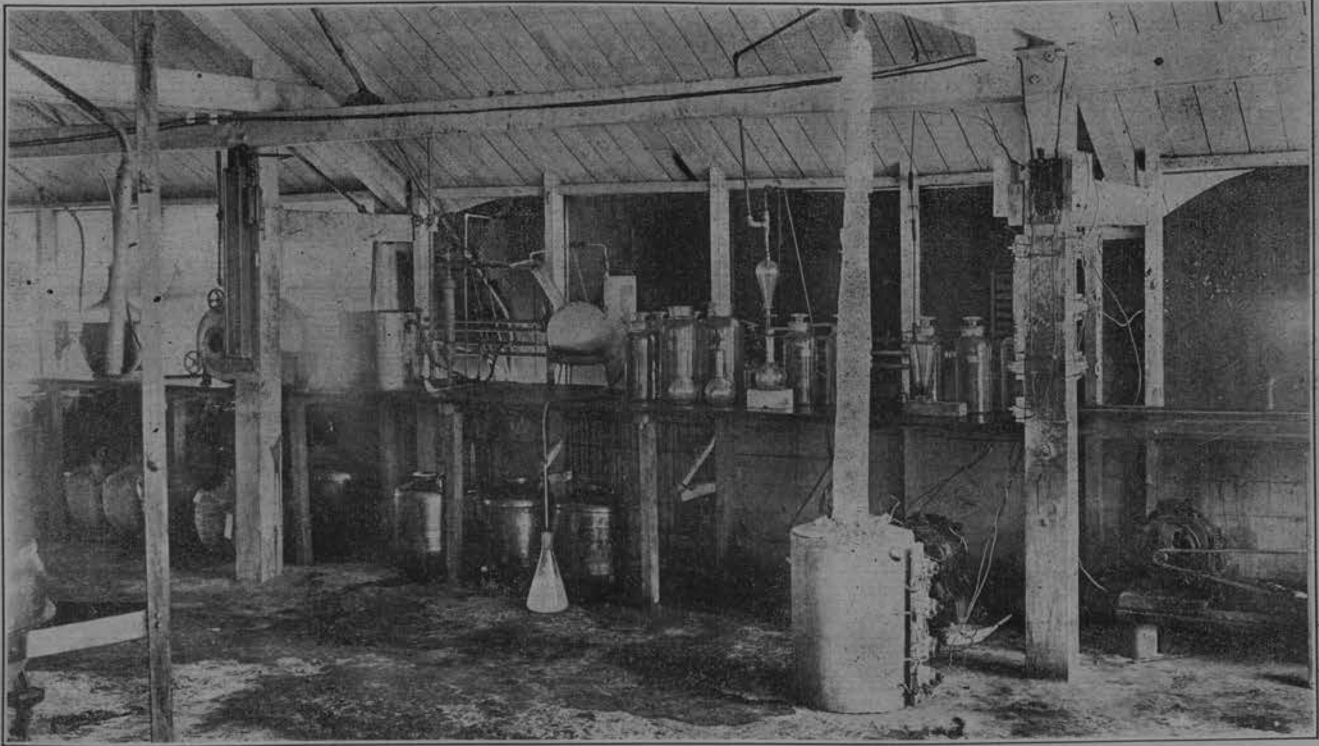

PLATE 1. VACUUM DISTILLATION OF ETHYL ESTER AT THE BUREAU OF SCIENCE

MANUFACTURE OF INDUSTRIAL ALCOHOL AND ALCOHOL MOTOR FUEL IN THE PHILIPPINE ISLANDS

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ONE PLATE AND THREE TEXT FIGURES

INTRODUCTION

Alcohol has been used for beverage purposes in the Philippine Islands since the earliest times. The production of alcohol for beverage and other purposes constitutes at the present time a very important industry, as is readily seen from Table 1 which shows the amounts of denatured (industrial) alcohol and fermented liquors produced annually from 1909 to 1920, inclusive.

TABLE 1.—*Distilled liquors and malt beverages manufactured in the Philippine Islands and the taxes collected upon them.*

Fiscal year.	Distilled spirits.		Denatured alcohol.	Fermented liquors.
	Manufactured.	Tax collected.		
	Proof liters.[a]	*Pesos.*[b]	*Proof liters.*	*Gauge liters.*
1909	9,532,537	1,899,043	26,672	3,636,499
1910	10,584,124	2,269,160	183,682	3,837,000
1911	10,471,299	2,551,501	380,099	3,887,500
1912	11,426,728	2,713,061	[c]721,262	4,466,250
1913	11,276,298	2,658,066	661,790	3,663,750
1914	11,847,354	2,729,705	820,148	3,915,000
1915	7,164,723	2,243,499	801,428	3,667,703
1916	10,350,363	2,747,396	735,753	5,720,769
1917	15,073,758	4,189,503	966,549	5,875,200
1918	15,931,402	4,476,443	867,971	4,236,200
1919	13,413,612	4,318,895	633,217	4.378,800
1920	16,019,612	3,976,938	[d]522,412	5,221,865

[a] Includes denatured alcohol exported tax free and medicinal tax-free alcohol. The proof spirit referred to throughout this article is that fixed by section 3249 of the Revised Statutes of the United States which defines proof spirit as containing one-half its volume of alcohol of a density 0.7939 at 60° F. The British proof spirit contains 49.24 per cent alcohol by weight.

[b] One peso Philippine currency equals 50 cents United States currency.

[c] Includes tax-free alcohol used for medicinal purposes.

[d] Exempt from specific tax but subject to 1 per cent on gross sales.

A large increase in the production of industrial alcohol can be confidently looked forward to, mainly because alcohol mixtures are being used in internal-combustion engines as fuel to replace gasoline. Incidentally, there is always the possibility of prohibition being extended to the Philippines, which would result in decreased production of beverage alcohol and increased production of industrial alcohol.

It is not the purpose of this article to discuss the production of alcohol for beverage purposes. On the other hand, a great deal of the information given applies to the manufacture of beverages from the rectified alcohol as well as to the manufacture of industrial alcohol and alcohol mixtures for motor fuel.

RAW MATERIALS FOR THE PRODUCTION OF ALCOHOL

The largest source of raw material for the production of alcohol in the Philippine Islands is undoubtedly the saps of the various native palms; of these, the sap of the nipa palm is most used. Another large source of alcohol is the molasses obtained as a by-product in the manufacture of sugar from sugar cane. Various cereals, cassava, bamboo, and other cellulose materials are also potential sources of alcohol. In fact, the potential sources of alcohol in the Tropics are illimitable, as can be readily appreciated by any person who has traveled in tropical countries. Table 2 shows the quantity and kind of raw material used in the production of alcohol in the Philippine Islands and the amount of alcohol produced during 1919 and 1920.

TABLE 2.—*Quantity and kind of raw material used in the production of alcohol in the Philippine Islands in 1919 and 1920.*

Source of alcohol.	1919		1920	
	Quantity used.	Proof alcohol produced.	Quantity used.	Proof alcohol produced.
	Liters.	*Liters.*	*Liters.*	*Liters.*
Nipa sap	57,770,157	5,887,208	51,730,608	5,148,315
Coco sap	3,500,159	456,980	4,309,671	525,643
Molasses	11,004,256	6,778,878	18,058,566	9,078,297
	Kilos.		*Kilos.*	
Hard molasses	----------	----------	1,373,925	924,888
Cane sugar	501,347	273,377	516,979	326,844
Grain	2,775	481	3,996	1,921
	Liters.		*Liters.*	
Others	18,728	16,688	16,206	13,275
Total production	----------	13,413,612	----------	16,019,183

In 1910, 93 per cent of the total amount of alcohol and alcoholic beverages produced in the Philippine Islands was distilled from the sap exuding from palm trees. In 1920, this value had fallen to 35.4 per cent, due mainly to the increased use of molasses. The utilization of palm saps at present is confined to a few small areas. There are great tracts well situated for exploitation which have not yet been touched. The cost of production of alcohol from various sources is given in Table 3.

TABLE 3.—*The cost in dollars,*[a] *United States currency, of the various kinds of raw materials required to produce alcohol.*[b]

	Cost of the raw material required to produce 1 liter.	
	100 proof.	180 proof.
Sugar beets at 5 dollars a ton; sugar content, 14 per cent.	0.032	0.058
Sorghum stalks at 3 dollars per ton	0.032	0.059
Sugar cane at 3.25 dollars per ton	0.028	0.050
Beet molasses at 15 dollars per ton	0.029	0.053
Cane molasses at 0.12 dollar per gallon[c]	0.032	0.059
Jerusalem artichokes at 5 dollars per ton	0.027	0.048
Cassava at 5 dollars per ton	0.019	0.034
Potatoes at 4 dollars per ton for culls	0.021	0.037
Sweet potatoes at 8 dollars per ton	0.031	0.056
Barley at 0.65 dollar per bushel of 48 pounds	0.041	0.074
Maize at 0.70 dollar per bushel of 56 pounds	0.037	0.066
Oats at 0.35 dollar per bushel of 32 pounds	0.046	0.082
Rye at 0.80 dollar per bushel of 56 pounds	0.051	0.092
Nipa at 0.00389 dollar per liter,[d] equivalent to 6.5 per cent alcohol	0.015	0.027
Coco at 0.005 dollar per liter, equivalent to 6.5 per cent alcohol	0.0384	0.069
Coco at 0.0062 dollar per liter, equivalent to 6.07 per cent alcohol	0.0488	0.088

[a] One dollar United States currency is equal to 2 pesos Philippine currency.

[b] From Bull. U. S. Dept. Agr., Bur. Chem. **130** (1910); nipa and coco data from Gibbs, Philip. Journ. Sci. § A **6** (1911) 104.

[c] The present price of molasses (February, 1922) is 3 centavos (1.5 cents) a gallon.

[d] Pratt, D. S., Philip. Journ. Sci. § A **8** (1913) 395, estimates cost of nipa at 0.0015 dollar per liter, which gives less than one-half the value computed for cost of alcohol from nipa tuba given in the above table.

MOLASSES

Among the waste products utilized for the manufacture of alcohol, molasses ranks first. In the United States the chief source of industrial alcohol is cane or black-strap molasses. This product has been used for the manufacture of West Indian rum for more than two hundred years, but the utilization of molasses in large quantities for the production of industrial alcohol is a development of the last few years. For the manufacture of alcohol, molasses far surpasses any other material except palm saps in the ease with which it can be manipulated. Some 300,000,000 gallons of molasses are annually available in the West Indies. Tank steamers carry this material to the distilleries located in New York, Boston, Baltimore, New Orleans, and other manufacturing centers. In 1920, 110,000,000 gallons of molasses were used for the production of industrial alcohol in the United States.

The Philippine Islands sugar crop of 1921 totaled 552,027 tons.[1] The molasses weight is about 25 per cent of the weight of the sugar produced. This gives an annual production of 23,000,000 gallons of molasses.[2] Only 20 per cent of this was utilized for alcohol. Practically no alcohol was made at the centrals, the molasses being transported to the distilleries, mostly in or near Manila. Molasses is at present being run to waste in some sugar centrals because of a lack of market for it. Negros Island alone produces annually 8,000,000 gallons of molasses. Production will undoubtedly be largely increased in the future.

It takes from 2.5 to 3 gallons of molasses (depending chiefly on the percentage of sugar in the molasses and on the efficiency of the plant) to make 1 gallon of 190° proof (95 per cent) alcohol. At the latter conservative figure, the present annual supply of molasses in the Archipelago is a potential source of approximately 7,800,000 gallons of alcohol. Besides the fermentable sugar, cane molasses also contains valuable salts which can be utilized for fertilizer. In fact, the price of molasses is largely based on its fertilizing value. As far as the writer can ascertain, no attempt is being made in the Philippine Islands to recover the nitrogen, potash, and phosphorus compounds contained in the lees in the manufacture of alcohol from molasses. Theoretically, if the ash of the burned bagasse and the salts of the molasses are returned to the soil, the latter suffers no loss, as the sugar formed consists of carbon, hydrogen, and oxygen, which can be obtained from air and water.

The potash and nitrogen content[3] is greater in Hawaiian molasses than in Philippine molasses, as is shown in Table 4.

TABLE 4.—*Fertilizer constituents of Philippine and Hawaiian molasses.*

Constituent.	Philippine.	Hawaiian.
	Per cent.	*Per cent.*
Potash	1.39	3.99
Phosphorus	0.38	0.21
Nitrogen	0.21	0.64

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[1] Commercial ton (2,000 pounds). One metric ton equals 1.1 commercial tons.

[2] One United States gallon equals 3.78 liters. One gallon of molasses weighs 12 pounds.

[3] Brill, H. C., and Thurlow, L. W., Philip. Journ. Sci. § A 12 (1917) 269.

The Hawaiian cane takes up more of these constituents, because the quantity available is greater due to the general use of fertilizers in the Hawaiian Islands. In many cases no fertilizer is added to the sugar lands of the Philippine Islands, and no attempt is made to return the fertilizer ingredients found in the ash of the bagasse and in the molasses. Thus, it is only a question of years before fertilization must be practiced or the land will become exhausted.

Fermentation of the molasses.—The methods of fermentation of molasses in the Philippines are crude, with consequent low efficiencies resulting. There is no distillery using modern yeast-culture machines and very few in which the dilution of the wort, the addition of acid and sulphate, the stopping of the fermentation at the highest alcohol content, etc., are scientifically controlled. Brill and Thurlow[4] have shown that sterilization of the molasses solution or the use of good water increases the efficiency markedly. Also the dilution of the molasses to a definite density (about 16.5 Brix) is essential. The addition of 2 grams of sulphuric acid and at least 0.4 gram of ammonium sulphate to every liter of ferment will increase the percentage of alcohol produced. The use of pure yeast culture is probably the greatest factor in obtaining the highest possible efficiency. They recommend 1 part of pure yeast-fermenting wort to 100 or 150 parts of ferment. The dilution of the molasses may be decreased by using the Molhant process of accustoming the yeast to fermenting in more highly concentrated solutions, with a consequent saving in heat necessary for distillation. Magné[5] cites the following figures with reference to the yield of alcohol according to the process employed:

TABLE 5.—*Yield of alcohol from molasses according to the process employed.*

Method of fermentation.	Yield of alcohol; per cent of theoretical.	Absolute alcohol per 100 pounds fermentable sugar.	Molasses (55 per cent fermentable sugar) necessary for 1 gallon absolute alcohol.
		Gallons.	*Gallons.*
Spontaneously in presence of wild yeast	40–60	2.9–4.4	3.5–5.4
Using compressed yeast	50–75	3.6–5.5	2.8–4.2
Using antiseptics	70–85	5.1–6.2	2.5–3.0
Operating with pure yeast	85–95	6.2–6.9	2.2–2.5

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[4] Loc. cit.

[5] Magné, J., Pamphlet on the Manufacture of Alcohol from Molasses and Cane Juice. New Orleans, La., U. S. A.

It is quite possible to obtain a yield of 85 or 90 per cent, yet 75 per cent is considered good practice in the Philippine Islands. Any improvement in the methods of fermentation and distillation of molasses would mean an increase of revenue to the Islands and larger profits to the manufacturer.

Other raw materials for the production of alcohol.—Any starch or cellulose material can be converted into alcohol by proper treatment; consequently, the raw materials for the production of alcohol, in the Tropics at least, are practically inexhaustible. Bamboo, cassava, the various palms, wood waste (sawdust), etc., can all be utilized; however, the nipa sap and waste molasses available will more than meet the demand for the next few years.

The yields of alcohol from various sources, given in Table 6, are what may be expected in large-scale production.

TABLE 6.—*Approximate yield of alcohol from various sources.*

Material.	United States gallons of 95 per cent alcohol per ton of 2,000 pounds.[a]
Sugar molasses	70
Sorghum stalks	13.5
Wheat	100
Barley	75
Potatoes	21.5
Sweet potatoes	37.5
Cassava	42
Bananas	14
Sawdust (soft woods)	21.5

[a] One United States gallon equals 3.78 liters.

Inorganic sources of alcohol.—The commercial production of alcohol from inorganic materials is a recent achievement. The general method involves the hydrogenation of acetylene to form ethylene, which is then dissolved in sulphuric acid; this mixture, containing ethyl hydrogen sulphate, is diluted and distilled, alcohol being given off. A cheap source of power is necessary to make such a process a commercial success. A plant for the production of alcohol by this method is now in operation in Switzerland. The process is not a feasible one for the Philippine Islands at present.

ALCOHOL AND ALCOHOL MIXTURES AS FUELS FOR INTERNAL-COMBUSTION ENGINES

Although the application of alcohol as a fuel for internal-combustion engines dates back more than two decades, it is only within the last four or five years that the problem has assumed practical importance. This is due to the enormous increase in the use of automobiles in the last decade and the world-wide application of crude oil to transportation. The powers of the world are even now engaged in a struggle to monopolize the available supplies of crude oil, for our present-day commerce is dependent very largely upon an adequate supply of oil.

In the United States alone the production of crude oil has increased about 140 per cent since 1909, and that of gasoline about 800 per cent; but the number of automobiles registered has risen 2,570 per cent. The consequent enormous demand for gasoline has been met, partly by increasing the boiling-point range, partly by extracting liquid hydrocarbons from natural gas, partly by cracking, and partly from stored reserves. According to the United States Geological Survey[6] the unmined supply of petroleum is, roughly, 6,000,000,000 barrels which, if the present rate of production is maintained, will be exhausted in about thirteen years. But the present rates of production and of consumption will undoubtedly be increased, thus bringing even closer the exhaustion of our oil supply. Therefore, the finding of a substitute for gasoline is of utmost, vital, and immediate importance. We must find some less-evanescent fuel, one that is inexhaustible or almost so. There is known at present only one; namely, alcohol.

The pioneer experimental work on the production of an efficient alcohol engine has been completed.[7] It has been found that in order to use alcohol efficiently, the following alterations in the present type of engine are necessary:

Increased compression.—Alcohol is more efficient in engines of low piston speed and long stroke. This is due to the slower flame propagation of alcohol vapor in comparison with gasoline vapor and its ability to stand higher compression (180 pounds per square inch) without preignition.

Preheating of air and alcohol vapor.—Alcohol will not vaporize at ordinary temperatures. The preheating necessary can be readily done by utilizing the exhaust, with an electrical contrivance for starting from the cold.

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[6] Mineral Resources of the United States, pt. 1 (1917).

[7] See Lucke, C. E., and Woodward, S. M., Tests on internal combustion engines on motor fuels, Bull. U. S. Dept. Agr., Off. Exp. Sta. 191 (1907). Strong, R. M., Commercial deductions from comparison of gasoline and alcohol tests on internal combustion engines, Bull. U. S. Geol. Surv. 393 (1909).

Reduced water-cooling circulation.—Alcohol does not give out as much heat in burning as gasoline, but needs high cylinder temperatures for efficient working.

Increased jet orifice of carburetor.—An alcohol engine needs the jet orifice enlarged so as to increase the fuel supply about 50 per cent.

Carburetor floats.—Either a metal float or a cork float having a baked coating of boiled linseed oil should be used instead of a shellac-coated float, as shellac is soluble in alcohol.

It is thus readily seen that alcohol cannot immediately replace gasoline. A fuel which can be used in the present type of engine is necessary to tide over the transition period during the change from gasoline to alcohol engines. Such a fuel is a mixture of alcohol with a more-volatile substance, such as benzol or ether.

ALCOHOL MIXTURES

Mixtures of alcohol with other substances have been in use for some time. The mixture most used in Europe is one of alcohol and benzol. The use of benzol makes the fuel dependent on a coal-tar industry, and such countries as South Africa, Australia, South America, the Philippines, etc., would have to import their benzol. Consequently there has been developed in South Africa and in Hawaii a mixture of alcohol and ether; since the ether is made from the alcohol, its manufacture is practically independent of any other industry.

In South Africa a fuel named "Natalite," or "Natilite," has come into wide use due to the scarcity and the high cost of gasoline during the World War. It has been patented in all countries throughout the world. This mixture contains 55 per cent of rectified alcohol, 44.9 per cent of ether, and 0.1 per cent of ammonia. In 1918 over 255,000 gallons of Natalite were produced from molasses in South Africa. At the present time the largest factory is at Merebank, Natal, the capacity of which has been increased to 2,000,000 gallons per annum.

In 1918, due to the scarcity of gasoline in Hawaii, there was developed by Mr. Foster, of the Maui Agricultural Co., a motor fuel very similar to Natalite which has been used very successfully in the place of gasoline. It consists of a mixture of 55.55 per cent alcohol, 42.78 per cent ether, 1.11 per cent kerosene, and 0.56 per cent pyridine; that is, 40 gallons of ether are added to 60 gallons of Formula No. 3 [to each 100 gallons ethyl alcohol add 5 gallons sulphuric ether, 2 gallons benzine (kerosene), and 1 gallon pyridine].

With either of these mixtures, ether being very volatile, the engine can be started even more easily than with gasoline. The pyridine or ammonia is added to neutralize any acids that might be formed in the fuel or in the combustion of the fuel, and it also serves as a denaturant.

These mixtures compare very favorably with gasoline in efficiency. That these fuels can even now compete with gasoline for airplane engines in the United States, where gasoline costs less than one-half what it does in the Philippines, is demonstrated by the United States Post Office Department[8] in its airplane mail service. Its tests show "a great increase in number of miles per gallon, an increase in power and a very marked saving in the quantity of lubricating oil used."

Table 7 shows the consumption of alcohol fuel at various speeds, the tests covering thirty-one nonstop flights between New York and Washington.

TABLE 7.—*Consumption of alcohol fuel in airplane engines at various speeds.*

Revolutions per minute.	Gallons per hour, alcohol mixture.
1,440–1,460	15.9
1,475–1,480	20.1
1,500	21.5
1,520–1,525	22.4

Tables 8 and 9 show the amounts of gasoline and alcohol fuel used by airplanes at varying speeds, and also the consumption of lubricating oil.

TABLE 8.—*Comparison of the consumption of gasoline and alcohol fuel in airplane engines at varying speeds.*

Revolutions per minute.	Gallons per hour.	
	Gasoline.	Alcohol mixture.
1,440-1,460	----------	15.9
1,475	24	20.1
1,500	24.17	21.5

These tests also proved that there was much less carbon formation when using alcohol fuel than when using gasoline, and the number of forced landings due to fouled spark plugs was reduced to the minimum.

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[8] Tunison, B. R., Chem. & Met. Eng. 22 (1920) 297.

TABLE 9.—*Comparison of the consumption of lubricating oil in airplane engines with gasoline and with alcohol fuel.*

Revolutions per minute.	Oil used with—	
	Gasoline.	Alcohol mixture.
1,440-1,460		4.5
1,475	4.65	4.2
1,500	4.95	

These alcohol mixtures have been thoroughly tested, and they compare very favorably with gasoline.[9] The mileage obtained is equal or superior to that obtained with gasoline; there is no carbon deposit left in the cylinder; the acids formed are neutralized by the pyridine or ammonia present, hence there is no corrosion; there is less tendency toward knocking, resulting in a smoother-running engine; the heat of combustion is lower, hence the engine is less liable to overheat; in case of fire it can be extinguished with water; an engine can be started more easily from the cold than with gasoline; there is less fouling of the spark plugs and lower consumption of oil.

Foster[10] points out that the addition of substances that would neutralize the acids formed by the explosive combustion of the alcohol-ether fuel has incidentally often resulted in retarding the production of corrosive compounds within the fuel itself. He states in his patent:[11]

> It is obvious that the production of a successful synthetic fuel for internal combustion engines involves not only the problem of protecting the engine from the products of combustion, but the far more involved problem of protecting the fuel itself from destructive action and the fuel storage and supply system from the deleterious effects resulting from such auto-destructive action of the fuel.

The use of ammonia as a neutralizing agent in alcohol-ether mixtures is open to the great objection that ammonia is very volatile. To obtain some idea of the rate of evaporation of ammonia the following experiment was carried out: An alcohol-ether-ammonia mixture of the same composition as Natalite was placed in open 60-cubic-centimeter beakers, 25 cubic centimeters in each beaker. The ammonia present was determined at certain time-intervals by titration with tenth normal hydrochloric acid. Litmus paper was used as an indicator, 20 cubic centimeters of distilled water being added to the sample before titration. The results are shown in Table 10.

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[9] Alcohol used alone is, of course, more efficient than are alcohol mixtures, when used in slow-speed engines with high compression.

[10] Sugar News 2 (1921) 524.

[11] United States patent 1,384,946.

Text fig. 1 shows the rate of loss of ammonia from Natalite fuel when exposed to the atmosphere. It is readily seen that a less-volatile alkaline substance than ammonia must be used as a neutralizing agent. Of the many possible compounds the only ones that are obtainable in large quantities and that are at the same time inexpensive are pyridine and aniline.

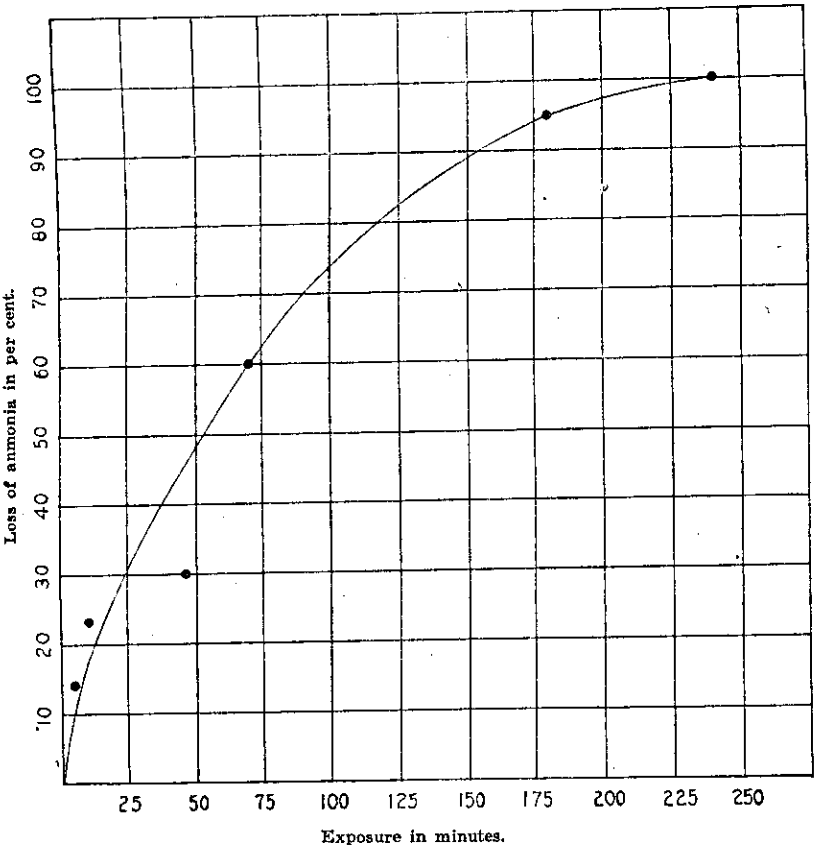

FIG. 1. Percentage loss of ammonia from Natalite fuel.

The writer has tested both Natalite and Foster's fuel in a Buick-Six model automobile. The shellac-coated cork float was replaced by one coated with glue. The spark was advanced to 30°. The air-fuel mixture was carefully adjusted. Table 11 shows comparative results with these fuels.

TABLE 10.—*Determination of the rate of evaporation of ammonia from a Natalite mixture exposed to the air. Temperature, 28° C.*

Duration of exposure to air.	0.1 *N* hydrochloric acid equivalent to 25 cc. of mixture.	Ammonia in 100 cc. of mixture.	Loss of ammonia.
Mins.	*cc.*	*mgs.*	*Per cent.*
0	4.3	29.3	
5	3.7	25.2	14.0
10	3.3	22.5	23.0
30	2.3	15.7	46.4
60	1.3	8.9	69.6
180	0.2	1.4	95.2
240	0.0	0.0	100.0

TABLE 11.—*Comparison of Shell gasoline with Natalite and with Foster's motor alcohol.*

	Shell gasoline.	Natalite.	Foster's motor alcohol.
Miles per gallon	13.6	11.9	12.0
Oil used	Mobiloil Arctic	Mobiloil Arctic	Mobiloil Arctic.
Ease of start from the cold	Must be choked	Starts readily	Starts readily.
Knocking under strain	Slight	None	None.
Pick up	Good	Good	Good.
Carbon formation in the combustion chamber	Marked	Slight	Slight.
Condition of spark plugs	Sooted	Clean	Clean.

Trouble was experienced at first due to clogging of the carburetor from dirt loosened by the motor alcohol. After a thorough cleansing of storage tank, vacuum tank, and carburetor, no further trouble was experienced.

If this fuel is to be successfully launched in the Philippine Islands it will be only the part of wisdom to insist upon a thorough preliminary cleansing of the gasoline system and a proper adjustment to both the fuel-air mixture and the spark. The normal setting of the spark for gasoline engines is 20 to 15° ahead of "dead center." The rate of explosion of alcohol fuel is less than that of gasoline and, consequently, the spark should be set at 25 to 30° ahead of dead center; or a safe rule to follow would be to double the advance recommended by the makers for gasoline.

A lesson should be learned from Cuba's experience with motor alcohol.[12]

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[12] Tillery, R. G., Louisiana Planter & Sugar Man. 67 (1921) 429.

Although the motor spirits industry cannot be said so far to be a complete failure in its competition with gasoline, certain facts with regard to the present consumption indicate that the demand is not increasing in the proportion that the producers had at first calculated upon. As a matter of fact, the consumption has apparently reached its peak, for the present at least, unless the manufacturers encourage it by producing a better product.

This situation has been brought about chiefly by the manufacturers themselves, through practices of their own rather than through any impossibility of a distiller's being able to produce an alcoholic motor-spirit which will compare favorably with the grade of gasoline now being sold on the Cuban markets. First of all, they attempted to sell the motor-spirits at a higher price than the relative value of the product in power development or mileage obtained as compared to gasoline indicated the motor-spirits to be worth. Second, they were instrumental in having a formula adopted by the Government which the present state of equipment of their plants could meet, and as a consequence, they are turning out a product which is inferior to all other motor-spirits which have been manufactured in other countries, and which have been determined by elaborate trials and experimental tests to compare favorably with the best grades of commercial gasoline. Third, they have not attempted to determine whether the engines in which comparative tests have been made in Cuba were properly adjusted for economic consumption of the motor-spirits and for efficient development of power, nor have they attempted to instruct the beginners in the proper manipulation of their engines during ordinary, every-day service, but rather have left it to the intelligence or ignorance of the chauffeurs to discover such matters for themselves.

The formula adopted by the Cuban Government was:

To 1,000 parts of alcohol of not less than 95%, add 0.5 part of formaldehyde, 8.00 parts of pyridine; and to every 100 parts of this mixture add 10 parts of gasoline or sulphuric ether, and 5 centigrams of methyl violet powder.

It will be noted that either gasoline or sulphuric ether may be used and, as not one of the distilleries was equipped to make ether, gasoline was used. To add almost 10 per cent of a product with which one is competing is not logical. Furthermore, a successful motor alcohol must have at least 40 per cent of a highly volatile liquid to compare favorably with gasoline. Cuba must either revise her formula and make a motor fuel containing at least 40 per cent of ether, or kill an industry which is capable of turning out 50,000,000 gallons of valuable motor spirits annually.

MANUFACTURE OF ALCOHOL-ETHER MOTOR FUEL

Alcohol distilleries now operating can easily make the alcohol-ether motor fuel by simply adding an inexpensive ether still and the requisite storage tanks to their present equipment. The ideal location for such a plant, however, is not in Manila but at the sugar centrals or in connection with a nipa swamp, thus eliminating the high cost of transportation of the raw materials and fuel. In the former case the waste steam from the central can be utilized to run the distillery; in the latter, the mangrove wood can be utilized as fuel.

Cost of production.—An economical plant should have a daily capacity of at least 1,200 to 2,000 gallons of motor fuel. Smaller plants cost relatively more to erect and to operate.

> A plant with a daily capacity of 1,200 gallons could be built in Hawaii in 1919 for $30,000, exclusive of buildings, boilers and fuel storage tanks. The cost of operation exclusive of molasses and steam will not exceed 10 cents (U. S. currency) and should not exceed 7 cents.[13]

A distillery of this size would require at least six fermentation tanks, with a total capacity of at least 100,000 gallons; four yeast tanks, with a total capacity of 15,000 to 20,000 gallons; a yeast-culture machine; an alcohol-rectifying still, 1,200 gallons daily capacity; two ether stills and scrubbers, 350 gallons daily capacity; and the necessary storage and mixing tanks. The capacity of the storage tanks would naturally depend upon shipping facilities, market, etc.

Another estimate[14] on cost figures, for an alcohol motor-fuel plant erected in the Philippines, is as follows:

Estimated cost of alcohol motor fuel plant producing 1,000 gallons per day.

	Dollars.
BOILER ROOM:	
1 75-horsepower steam boiler	1,572.00
Oil and water feed pumps, general fittings, etc.	2,000.00
FERMENTING ROOM:	
1 molasses scale	400.00
2 7,500-gallon mixing tanks	388.00
12 6,500-gallon fermenting tanks	2,164.00
3 2,000-gallon yeast tanks	212.00
3 250-gallon yeast tanks	58.75
2 pumps	400.00
STILL ROOM:	
1 modern copper continuous still, producing alcohol of 96–97 per cent in one operation	6,000.00
2 1,000-gallon charging tanks	115.00
1 1,000-gallon singlings tank	57.50
DENATURING WAREHOUSE:	
2 2,000-gallon metal receiving tanks	440.00
Denaturant storage tanks	250.00
1 500-gallon denaturing tank	100.00
1 air compressor	200.00

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[13] Report of the Committee on Manufacture of Sugar and Utilization of By-products. Hawaiian Sugar Planters' Association (1920).

[14] Oscar Krenz Copper & Brass Works Inc., Sugar News 2 (1921) 591.

Estimated cost of alcohol motor fuel plant producing 1,000 gallons per day—Continued.

	Dollars.
ETHER ROOM:	
1 modern sulphuric ether generator	3,500.00
1 1,000-gallon supply tank	57.50
1 ether storage tank, metal, 1,000 gallons	144.00
FINISHED MOTOR FUEL STORAGE ROOM:	
2 5,000-gallon tanks	368.00
1 1,500-gallon mixing tank	58.00
1 pump	200.00
GENERAL:	
All piping throughout plant	2,000.00
Miscellaneous expense	1,815.25
BUILDINGS:	
Greatly varying as to type of construction, preparation of site, location, materials, etc., estimated at	12,500.00
Grand total	35,000.00

These figures are evolved from the result of practical experience in the erection and operation of numerous distilling plants and the particular experience of the erection of one motor fuel plant. The equipment figures and supply costs are based on current prices at San Francisco, California; plus freight charges delivered to Manila, P. I.

While the technical and engineering side of * * * [these] figures have been very carefully worked out allowance must be made in the items of labor, insurance, overhead, depreciation, etc. [see pp. 32 and 33]. Those items being governed by local conditions will vary somewhat. The figures used are reasonable and conservative. In the item of buildings also there can be some variance; however, the figure used is great enough to take care of the general type of buildings that would be called for in this kind of plant. Under favorable conditions this sum would be somewhat less, whereas under conditions where there would be much excavation or grading to be done, the estimated figure would be exceeded. No allowance has been made for ground site, it being assumed that such a plant would be erected on plantation premises so that this would not be an item of expense. The item of Molasses also is not charged for two reasons, first because molasses at the raw sugar mill is generally considered a practical waste, and second, because of the fertilizing value of the spent slop. This alone is generally conceded to be great enough to more than offset any reasonable costs for molasses. Inasmuch as an alcohol motor fuel plant would best be placed immediately contiguous to a raw sugar mill, there should not even be transportation costs in getting molasses into the motor fuel plant.

The ether can be made for less than 10 per cent over the cost of alcohol.[15] There are, however, two more-recent methods for manufacturing ether from alcohol which utilize the alcohol in the vapor phase. A purer product and higher yield are obtained at a lower cost than by the lead-still method.

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[15] Humboldt, E., Power 50 (1919) 420.

The first method[16] consists of superheating the alcohol vapor to the right temperature, then passing it through a chamber containing lead balls over which sulphuric acid is allowed to drop slowly. Transformation to ether occurs instantaneously, the alcohol being in contact with the sulphuric acid only momentarily. The ether vapor is then passed through a washer containing caustic soda and then to a rectifying column to separate it from water and alcohol. About 3 pounds of acid and 14 pounds of soda are required for every 100 pounds (13.9 gallons) of ether made. This process is being used successfully in the Natalite factory at Merebank, Natal.

The second method is a catalytic process and eliminates the use of sulphuric acid and caustic soda. The alcohol is passed through a superheater and then over alumina. acting as a catalyst. The temperature of the vapor and catalyst must be kept constant at about 200° C. If the temperature rises above 200°, ethylene is formed. By passing the outgoing vapors through tubular heat exchangers to heat the incoming alcohol, a small superheater is the only necessary heating apparatus; the amount of heat necessary for the conversion is less than 10 per cent of that required in the lead-still process.

The estimated daily operating cost is given by Krenz[17] as follows:

Estimated daily operating cost of alcohol motor fuel plant producing 1,000 gallons per day.

		Dollars.
19.34 tons average cane molasses		000.00
No. 34 66 Be. sulphuric acid, 2.5c per lb.		.85
No. 14 caustic soda, 5.4c per pound		.76
21 gals. benzene, 50.0c per gal.		10.50
10½ gals. pyridine, $1.86 per gal.		19.53
40,000 gals. water, diluting, condensing, etc., pumping cost of 10c per 1,000 gals.		4.00
6½ bbls. fuel oil, $7.28 per bbl.		47.32
LABOR:		
1 fermenting room man and foreman, day shift	5.00	
2 distillers, night and day shifts, 3.00	6.00	
1 denaturer, day shift	3.00	
1 ether man, day shift	3.00	
2 firemen, day and night shifts, 3.00	6.00	
1 laborer	2.50	25.50

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[16] Annaratone Process, French patent 408,089.

[17] Oscar Krenz Copper & Brass Works Inc., loc. cit.

Estimated daily operating cost of alcohol motor fuel plant producing 1,000 gallons per day—Continued.

	Dollars.
Interest at 8% on $35,000 over 312 working days, per day	8.97
Insurance on ⅓ plant value, premium 3.00 per 100 per year, per day	.11
Depreciation at 10% per year, $3,500; per day	11.21
Office expense, general overhead, etc., per day	10.00
Grand total	138.75

The above estimate shows that the cost of producing one gallon of alcohol from molasses, exclusively of the cost of molasses, is 13.87 cents (27.74 centavos). Mr. Foster computes the cost of operation to be 14 to 20 centavos, exclusive of molasses and steam. The fertilizer recovered from the lees practically covers the cost of the molasses. In the Philippines alcohol-ether motor fuel can undoubtedly be made to yield a handsome profit when sold at 50 to 70 centavos a gallon.

In Natal the original Natalite company showed a profit of 38 per cent in 1920. The original 5-pound shares of the parent company are now quoted at 105 pounds Sterling. When Natalite was placed on the market in Natal at 52 cents, gasoline was selling for 1.50 dollars. To-day there are several centers where gasoline is entirely off the market.[18]

In the Philippines, during the World War gasoline reached as high as 3 pesos a gallon. The present price is 1.15 pesos in Manila. At a price considerably lower than this, alcohol motor fuel can more than successfully compete with gasoline.

The present annual supply of molasses in the Philippines is a potential source of some 7,800,000 gallons of alcohol. The consumption of gasoline for 1920 was 9,160,000 gallons. Therefore, the Philippine Islands could almost supply its own needs for motor fuel by simply utilizing its present supply of molasses for such production. Since the nipa sap available is many times as great as the molasses supply, and is an even cheaper source of alcohol, the country is in a position not only to supply its own needs, but to export as well.

SUMMARY

The nipa palm and molasses offer cheap and easily manipulated sources of alcohol for use as a motor fuel.

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[18] Wilson, Sugar News 2 (1921) 228.

Alcohol, alone, will probably not be used as a motor fuel until a new type of high-compression, slow-speed engine is developed.

Alcohol mixtures to-day are being used on a large scale in the present type of gasoline engine with simple alterations. These mixtures offer many advantages and no disadvantages over gasoline and are more efficient than gasoline.

Although no alcohol motor fuel is being manufactured at present in the Philippine Islands, two distilleries are installing the necessary apparatus for its manufacture. Utilization of waste molasses and of the unlimited supply of nipa sap in the production of alcohol motor fuel would not only make the Philippine Islands independent of other countries for its supply of motor fuel, but would also constitute a very valuable addition to the industries of the Islands. Since modern industry largely depends on an abundant and cheap supply of motor fuel and since in time of war the price of imported fuel goes skyward and the supply is curtailed, the establishment of an industry supplying motor fuel from the natural resources of the Archipelago will be of immense value to the Philippine Islands.

THE BURI PALM

The description and uses of the buri palm, *Corypha elata* Roxb., can be found fully discussed in another article.[27] The sap is used only to a small extent in the Islands at present and gives small promise of any large future development. In many places in the Philippines the inhabitants have every need supplied by this palm: bread from the pulp; sweetmeats from the young fruit kernels; houses from the leaves; hats, mats, ropes, and baskets from the leaf fibers; shoes from the bark; and sugar and wine from the sap.

In India, Australia, Malaysia, and other places various other species of palms yield saps which are utilized for making toddy and arrack, corresponding respectively to our tuba and vino. Among the palms thus utilized may be mentioned *Arenga saccharifera* Labill., the sugar palm; *Borassus flabellifer* Linn., the Palmyra palm; *Caryota urens* Linn., the fish-tail palm; *Phoenix dactylifera* Linn., the date palm; and *Phoenix sylvestris* Roxb., the wild date palm.

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[27] Gibbs, H. D., Philip. Journ. Sci. § A 6 (1911) 167.

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SUPPLEMENT

Supplementary to this paper is given a résumé of articles published by the Bureau of Science on the utilization of palm saps as a source of alcohol; most of these publication are out of print.

THE NIPA PALM, NIPA FRUCTICANS WURMB

The nipa[19] is an erect, stemless palm, the leaves and inflorescences arising from a branched rootstock, the leaves pinnate, 3 to 10 meters long. Inflorescence from near the base of the leaves, erect, brown, 1 to 1.5 or 2 meters high, bearing numerous sheathing spathes and both male and female flowers, the former lateral, catkin-like, the latter terminal in a globose head. Fruit nodding, globose, as large as a man's head or often considerably larger, consisting of many obovoid, 6-angled, 1-celled, 1-seeded carpels, the free parts pyramidal, the pericarp fibrous, the seed large, white, hard.

This species of palm grows in great abundance throughout the Archipelago in the tidewater estuaries and tidal rivers or other places flooded by the tides with brackish water. It does not thrive in either fresh- or salt-water marshes. Plate 1 shows the distribution of nipa swamps in the Islands.

* * * Rated in order of size, irrespective of their present commercial importance, the most extensive areas are situated as follows:

Portions of the provinces of Pampanga and Bulacan bordering on Manila Bay, Island of Luzon. Province of Capiz, Island of Panay. The valley of the Cagayan River, Island of Panay. The valley of the Cagayan River, Island of Luzon. The valleys of the Catubig and the Gandara Rivers in the Island of Samar. The Province of Pangasinan, Island of Luzon. Surigao, Island of Mindanao. The Province of Tayabas, Island of Luzon.

The other nipa areas of the Philippines do not compare in size with those listed above.

In this connection it might be well to point out that the tidewater flats on which the nipa flourishes also produce various species of mangrove. The mangrove furnishes a valuable source of fuel which in virgin stands could be utilized for the distillation of the nipa sap. The virgin mangle has long since disappeared from the region around the upper part of Manila Bay. In this district cultivated mangrove swamps are found from Malabon on the east to Bálanga on the west side.

Nipa[20] and bakauan [a species of mangrove most used for firewood] are planted extensively in solid stands, but there is little planting of other swamp species.

Hundreds, and may be thousands, of hectares are planted to bakauan, which is grown for firewood, and sold principally in the Manila market, this wood being preferred to almost all others for fuel. The Manila supply is inadequate, as is indicated by the remarkably complete utilization of the swamps in the vicinity, and by the use of other and inferior species.

[19] Gibbs, H. D., Philip. Journ. Sci. § A 6 (1911) 99–206. Since reprints of this article are exhausted, part of it will be quoted in full, other parts abstracted and brought up to date.

[20] Brown, W. H., and Fischer, A. F., Philippine Mangrove Swamps, Bull. P. I. Bur. Forestry 17 (1918) 94.

No records seem to exist as to how, when, and where bakauan was first cultivated, but it is safe to say that the present planting methods have been in use for at least three generations. An evident reason for the cultivation is the large agricultural population on the level lands of Pampanga Province and the accessibility of the Manila market.

In the municipalities of Macabebe, Guagua, Lubao, Sexmoan, and Orani there are a number of barrios along the rivers which have a population that divides its labor among the fishing, bakauan, and nipa industries.

Table 3 shows us that the nipa juice is the cheapest source of alcohol available. It is also cheaper to produce alcohol from nipa than from grains or even from molasses, as it is not necessary to dilute the sap with water or even to seed it with yeast. Not only do the palm saps ferment readily, due to the wild yeast always present, but they ferment very rapidly so that the fermentation is often complete in less than twenty hours. The elimination of pure water necessary for dilution, pure yeast for seeding, addition of chemicals, and the shortening of the fermentation period all mean considerable saving in the production of the alcohol.

There are at present only a few nipa districts utilized for the collection of nipa tuba as a source of alcohol. Most of these are in the nipa area on Luzon in Bulacan and Pampanga Provinces. This district extends along Manila Bay for about 32 kilometers with an average width of 5 kilometers. A considerable portion of it is controlled by various large distilleries. Only about 30 per cent of the total area of the district is at present utilized. Some of the nipa areas near Manila have been converted into fish ponds which seem to yield a greater income per hectare than does nipa at present.

LABOR CONDITIONS IN THE NIPA SWAMPS

The best managed *nipales*, or nipa groves, are divided into sections of about 1 hectare, containing from 700 to 800 producing plants in every hectare, each of which is assigned to the care of one or more men. Usually two men are required to handle 1 hectare and the work of cutting the plants, gathering and transporting the *tuba* to the distillery and the general care of the grove is divided between them. Since the sap not only has a recognized commercial value at the distillery, but is also greatly prized by the natives as a beverage, a close watch by the guards is necesssary.

The sap, as it drops from the flower stalks, is collected in hollow joints of bamboo. Each plant is visited daily and the sap brought to the distillery in *bancas* of light draught which the natives paddle in and out of the waterways. Sometimes the *tuba* is emptied into large earthenware jars and these are transported to the distillery, and, again, it is emptied directly into the boat. A nipa leaf is cut and placed in the banca over the *tuba* to prevent undue slopping, and thus, more or less immersed in the partially fermented *tuba*, the boatmen make the trip. The time for gathering the sap is in some measure dependent upon the tides, for many of the small waterways are navigable only with difficulty or else are impassable at low tide, even for such a light draught vessel as the native canoe. The collection in some localities begins at 1 o'clock in the morning and is completed within 6 hours.

The laborer in the nipa groves builds himself a house of nipa leaf thatch with bamboo framework, on the bank of a stream on the nipa estate. Fish, the principal article of food, are easily caught in these places. Here, usually with a large family, he lives in peace and contentment.

The communities in these nipa areas are old-established ones, and undoubtedly attempts to establish new communities to-day for work in the swamps would be a difficult matter. More inducements would have to be offered than were offered in the past; medical attention, stores, and amusements would have to be included, barrios constructed, and a water supply provided in order to obtain the laborers and keep them contented.

PROPAGATION OF THE PALM

The nipa palm reproduces from seed and also by the branching of its roots. The original seed produces two plants, each of which in turn produces two more at the growing points formed by the branching of their roots, and so on. Hence the life of a nipa swamp is indefinite. It is said that care must be taken not to bleed both of two root-connected plants at the same time as in that case the plants will die. When the palms are raised from seed, the planting is done just before the *tuberos* begin the first harvest. The seeds are put in about 2 meters apart, making 100 seeds per *loang* (about 0.04 hectare). The plants begin to bear in about five years. By that time each plant has four growing points, about 1 meter distant from each other.

HARVESTING OF THE NIPA SAP

Conrado and Zobel[21] enumerate the following operations that are connected with the collection of the sap:

The *hauan*, or "clearing up."
The *sicat*, or "kicking the stem."
The *talog*, or "cleaning the stem."
The *pucao*, or "working of stem to make it soft and limber."
The *patit*, or "cutting of the stem."
The *cortes*, or "daily sectioning of the stem."

The "clearing up" is usually done in July or August. The nipales are parceled to the tuberos who are required to clear them of underbrush, dead leaves, etc. Since the nipa sends its inflorescence up from the base and hence is near the ground, the flower stalk is conveniently situated for tapping and for gathering of the sap. The nipa bears small fruits in its fourth year but is not usually tapped until its fifth year. The stalks of the chosen fruits (nearly full-grown ones) are stripped of leaves and are kicked at the base about five times at intervals of about a week, several kicks being given each time. This is to start the flow of tuba. The stalk is then cut across near its top, usually just below the fruit, and each day a thin slice is removed to keep the wound fresh and to facilitate exudation. When a plant bears two flower stalks the usual practice is to draw sap from only one, the other being removed and the stem allowed to dry.

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[21] Conrado, A., and Zobel, E., Estudio de la planta llamada "nipa" de su cultivo y de sus propiedades. Imp. y lit. de "La Concepción," Marques de Comillas No. 3, Manila (1906).

The sap is collected in bamboo joints, called *tuquils* (Pampangan), or *bombones* (Spanish), which are hung upon the stem. The receptacles are about 45 centimeters high and 8 centimeters in diameter and have a capacity of about 2 liters.

One stalk normally flows for about three months, but it is not uncommon for it to be entirely cut away, at least so close to the ground that it can no longer be utilized by the daily paring of small slices, long before the flow has ceased. In some districts the flower is cut before the fruit is formed, and under such circumstances the daily yield of sap is said to be increased but the period of flow reduced from three to one and one-half months, the total yield being practically the same in both cases. The plant seemingly is not affected by this treatment. A recent report by Dr. G. A. Perkins[22] gives the following data on harvesting of the sap:

> The *tuberos* are alloted bamboo from which to make *tuquils* and also are alloted bancas, in which they transport the *tuba*. These bancas are mostly hired by the company at 3 to 8 pesos per month (now about 6 pesos). About 120 tuberos are required for the first harvest (2,000 hectares). Each man handles about 1,000 producing palms. The harvest begins in July when the fruits are cut, but most fruits are reserved until the end of the floods (about August 20). The harvest ends about December 20, not all fruits being cut at the same time. Each fruit stalk flows about two and one-half months.
>
> The second harvest is from December 20 to April 10 requiring 80 tuberos who work about 800 plants each. The tuquils surviving the first harvest are used. No fruits are usually cut from April 10 to the last of June, but for the sake of having yeast for fermenting molasses a third, or "extra," harvest is often taken by reserving fruits which could be cut in the second harvest. In 1920, 44 tuberos were employed on one

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[22] An unpublished report.

estate in the third harvest, each tubero handling about 500 stalks. The tuberos receive 7 centavos per *tinaja* (36 liters). This includes all work in preparation for harvest, but bancas and bamboos are supplied to the tubero.

The only known disease of the nipa plant is *absic,* which is caused by insect attack on the leaves. Rain kills practically all the insects, but sometimes it is necessary to cut the infected leaves.

The number of plants per hectare.—The number of plants per hectare varies within wide limits depending upon whether the swamps are cared for or overgrown, the former condition naturally giving superior plants. A conservative estimate for cultivated nipales, or nipa swamps, can be placed at 2,000 to 2,500 palms per hectare, of which 750 can be depended upon to produce fruiting stalks. Intelligent care and selection of seed undoubtedly would raise the yield of sap and the percentage of sugar in the sap.

Yield of sap.[23]—The estimates of the yield of sap vary within very wide limits. A distiller who has had much experience in the *nipales* believes that each producing plant will average 1.25 liters daily, and a chemist at one time employed by one of the distillers has stated that an average plant will flow 50 liters during the season.

The yield per hectare has been estimated by many different writers and distillers and it is evident from a perusal of the figures that many are mere guesses. The number of plants per hectare is estimated by a chemist in the employ of one of the distillers to be 2,500. Internal Revenue Agent G. A. Ruge believes the municipalities of Abulug and Pamplona in the Province of Cagayan to have *nipales* containing 4,600 plants per hectare. A distiller of wide experience told me that the number is 700. If this latter figure is taken to be 700 plants producing at the same time I have no doubt that it is fairly accurate for the areas controlled by his company. He also stated that they obtained in actual practice 438 liters per hectare daily during the season. This is equivalent to 78,480 liters yearly per hectare, a figure quite close to my estimates. Other figures, not so reliable, go as high as 225,000 liters per hectare.

It is to be remembered that while wild nipa swamps may contain 4,000 plants per hectare, the percentage of producing plants and the amount of sap which each plant yields will be less than in the cultivated districts. In the uncultivated areas a small proportion of the trees is accessible; in the cultivated, the plants are thinned, and there are more waterways, and yet the yield of sap per hectare is greatly increased. A yield of 75,000 liters of tuba per hectare per year would be extremely satisfactory to the distillers, and I believe this amount is seldom reached in the best managed *nipales.* It should, however, be exceeded. Some operators obtain only 4,000 liters per hectare during a full season.

In the year 1909 one of the largest producers obtained 8,700,000 liters of tuba from an estimated area of 1,000 hectares which is at the rate of

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[23] Gibbs, H. D., op. cit. 117.

8,700 liters per hectare. Less than one-third of this area was producing, partly from lack of labor and partly because the greater portion of the estate had not been made accessible to the distillery. The alcohol production from this yield was about 5 per cent.

The atmospheric and climatic conditions affect the flow of sap. The natives working among the plants are positive that they can predict the approach of a storm by a sudden checking, in some cases amounting to almost a stoppage, in the flow, occurring about three days before the arrival of the typhoon. It is stated that after a temporary stoppage has been produced by meteorologic conditions an increased flow will start which will balance the period of inactivity.

The seasonal variation in the composition of the fresh tuba must be slight, although when received at the distilleries the differences, both in quality and quantity, are very great. This is undoubtedly due to the fact that rains dilute the juice after it has flowed from the flower or fruit stalk. The gain in volume is balanced by the loss in sugar and alcoholic content.

As a result of experimental work performed by Gibbs and others, an estimate of the yield of sap per plant per season is given as 43 liters, in a nipale cared for under average conditions according to present methods. This means an average daily yield of 0.58 liter and a total yield of 87,000 liters per hectare per year. The average flow of sap during the season is well shown in fig. 2.

The following data were obtained by Gibbs[24] on six trees:

	Liters.
Total flow from six trees	260.286
Greatest total flow from a single tree	49.410
Lowest total flow from a single tree	36.335
Average seasonal flow per tree	43.381
Average daily flow from six trees	3.470
Greatest daily flow from one tree	1.770
Average daily flow per tree	0.579

The composition of the sap.—From analyses made by Mr. Francisco Agcaoili, of the Bureau of Science, the following is the composition of a good quality sap:

Brix	17.0
Density $\frac{15°}{15°}$	1.020
Total solids	18.00
Ash	0.48
Acidity	Trace.
Sucrose	17.00
Reducing sugar	Trace.

An invertase proferment, or zymogen, also occurs in the sap.

Changes in the composition of the sap.—The inversion of the sucrose and the alcoholic, acetic, and other fermentations begins almost immediately after the sap drops from the stem into the tuquil under ordinary local conditions of collection. When the sap arrives at the distillery the inversion is complete and the alcoholic fermentation has begun and is sometimes completed. The juice is now milky in appearance and covered by a thick layer of foam. When the sap is collected in clean vessels the inversion does not begin for four or five hours. A white flocculent precipitate is slowly formed. The inversion of the sugar begins at the same time. Gibbs has shown that a zymogen present in solution in the sap causes the separation of a white flocculent invertase which rapidly attacks the sucrose present. He found that if clean tuquils are used and limed with thick lime cream, the sap collected in them will remain unchanged for more than ten days.

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[24] Op. cit. 121.

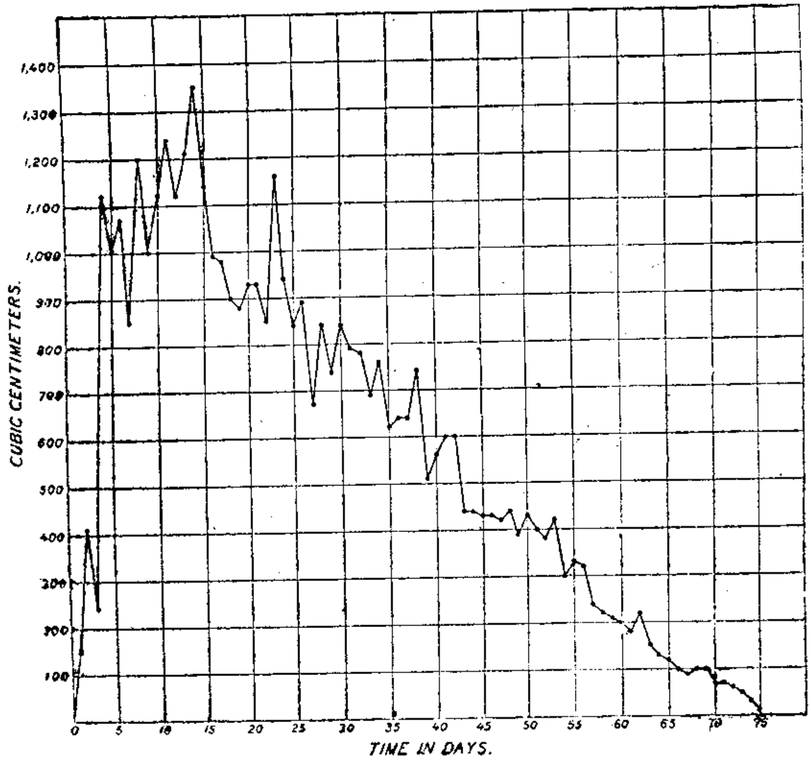

FIG. 2. Sap flow of nipa palm, average of six trees during one season.

The rate of inversion of the sugar and the rate of formation of alcohol and acid are well brought out in fig. 3.

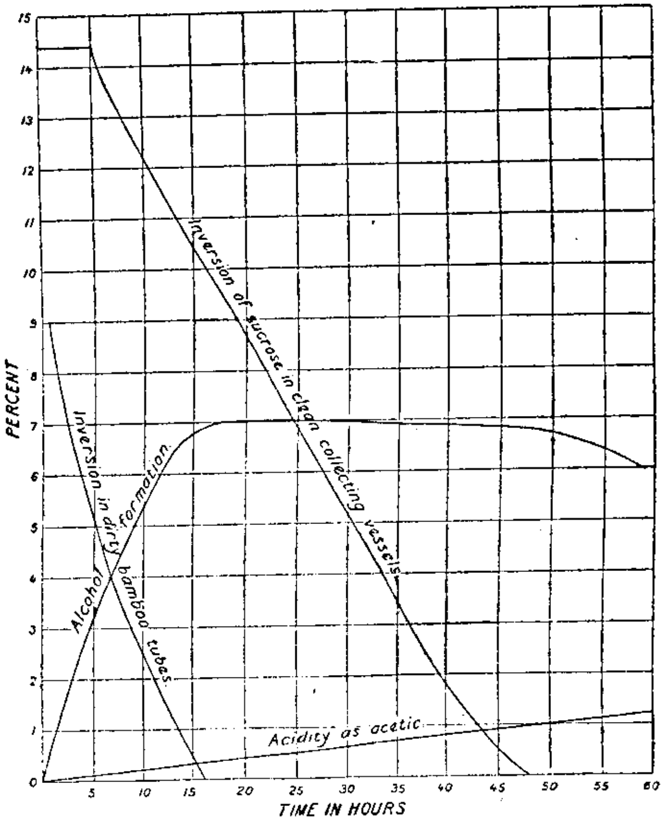

FIG. 3. Spontaneous fermentation of the nipa palm sap.

DISTILLERIES FOR NIPA TUBA

Twelve provinces from time to time have been engaged in the industry of distilling nipa sap. The tendency has been toward a decrease in the number of distilleries operating, the primitive and inefficient distilleries being crowded out by more-modern and more-efficient plants, the production of alcohol increasing to some extent. In the nipa district bordering Manila Bay all the distilleries use continuous rectifying stills, producing either 100° to 120° proof alcohol or high-grade alcohol of 180° to 190° proof.

Fermentation.—The nipa tuba as received by the distilleries is already partly or wholly fermented. It contains, besides the desirable wild yeast, many undesirable organisms. The tuba is placed in wooden or concrete fermentation tanks and allowed to ferment. The fermentation is usually allowed to proceed until the foam subsides or the temperature of the ferment falls.

The time allowed for fermentation varies from thirty hours to three days. It has been shown that even thirty hours is too long, much of the alcohol being changed into acetic acid by that time. Most of the large distilleries now ferment a mixture of molasses and nipa, the latter usually containing enough invertase and wild yeast to change the sugar in the molasses rapidly to alcohol. Molasses thus becomes a cheap source of alcohol and the distillery is often able to operate during the entire year, even during the season of small sap production. At certain seasons of the year, however, the nipa sap seems to have a detrimental effect on the production of alcohol from molasses, only 1 or 2 per cent of alcohol being obtained. This is due to the killing of the yeast by the acid bacteria. In some distilleries no attempt is made to check fermentation at the highest alcohol content. This means that, while the wash is stored before going to the still, a loss of alcohol occurs due to acid fermentation. In some cases, the high acidity of the beer is neutralized by lime made on the spot by burning oyster and other shells. Fermentation can be checked at the proper moment by the addition of an excess of lime to the wash, and then the latter can be stored without appreciable change to await its turn to be run to the stills.

Distillation.—Distillation is usually accomplished in either pot stills or continuous rectifying stills, the former usually heated directly by wood or wood and coal fires, the latter by steam coils. The first distillate from the pot stills is collected until it has the requisite percentage of alcohol (20 to 50) desired for beverage purposes. The distillation is further continued until most of the alcohol has passed over. The pot is then emptied and the second fraction poured back to form part of the next run.

The continuous stills give alcohol up to 100° proof. The rectifying stills yield an alcohol as high as 190° proof. The losses that occur are largely in the waste which contains sometimes as high as 1 per cent of alcohol.

THE COCONUT PALM

The cultivation of the coconut palm and methods of obtaining the sap from it are fully described by Gibbs.[25] Large numbers or palms are utilized exclusively for their sap, which is made into the native drink *vino de coco*. This is a misnomer, for vino de coco is not a wine, but a distilled liquor containing from 20 to 50 per cent of alcohol.

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[25] Op. cit. 147.

There is more labor involved in obtaining the sap from the coconut palm than from the nipa because of the height of the trees. To facilitate the collection bamboo poles are usually attached from tree top to tree top, forming bridges upon which the collector can travel from tree to tree without descending to the ground until his receptacle is full. Since the coconut blossoms throughout the year the tuba season is continuous, and when one stalk is exhausted another is tapped. Usually not more than two stalks on a tree are tapped at the same time.

The yield of sap.—The flow of sap varies with the age of the flower stalk, age and condition of the tree, character of the soil, and climatic conditions. The rate of flow is less during the heat of the day than at night. A tree will grow about ten stalks annually, and each will run sap for about two months. A tree is in its prime when about 40 years old. An investigation of seven distilleries in Tayabas Province revealed the fact that the average daily production from 5,785 trees from April, 1909, to March, 1910, inclusive, was 0.65 liter per tree.[26]

Gibbs found, however, that trees when properly handled by a sufficient number of men would yield approximately 1.4 liters per tree daily.

Composition of the sap.—Fresh sap in which no chemical change has occurred, taken from an average tree in its prime, will probably have about the following composition:

	Grams in 100 cc.
Density	1.0700
Total solids	17.5
Acidity	Trace.
Ash	0.40
Sucrose	16.5
Invert sugar	Trace.
Undetermined nitrogenous compounds, etc.	0.60

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[26] Op. cit. 154.

ILLUSTRATIONS

PLATE 1

Map of the Philippine Islands, showing distribution of nipa swamps.

TEXT FIGURES

FIG. 1. Percentage loss of ammonia from Natalite fuel.
2. Sap flow of nipa palm, average of six trees during one season.
3. Spontaneous fermentation of the nipa palm sap.

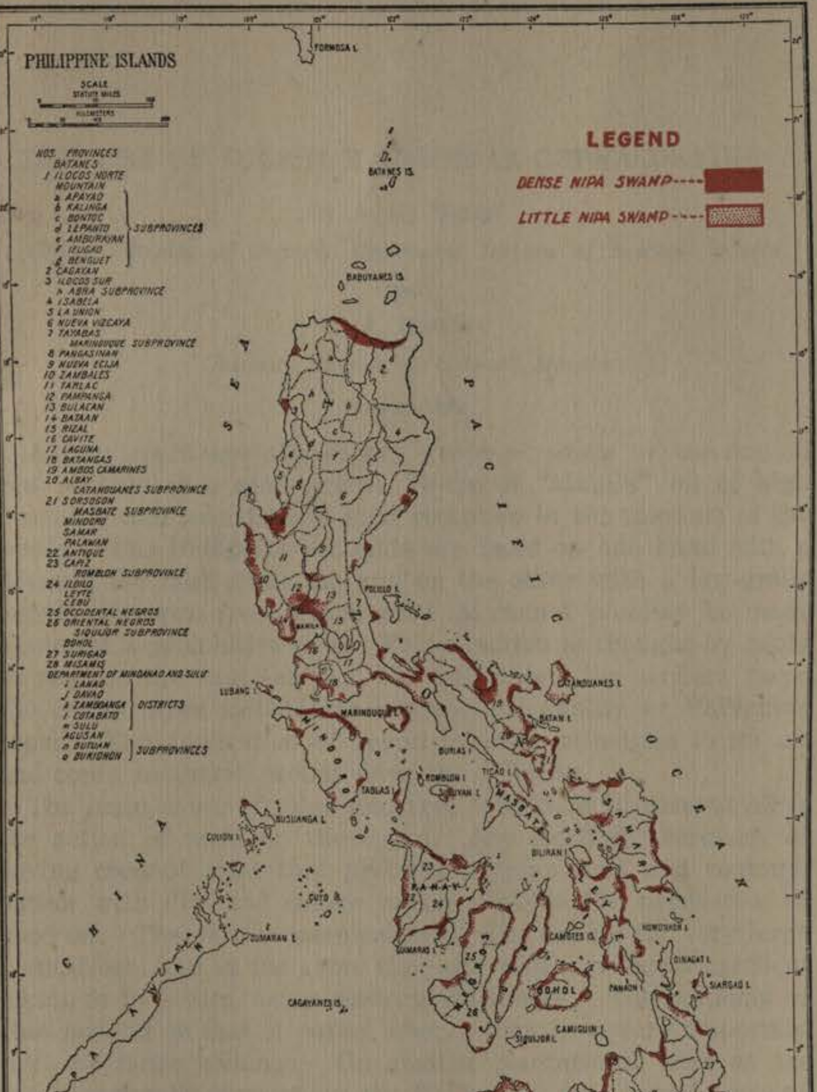

PLATE 1. THE PHILIPPINE ISLANDS, SHOWING THE DISTRIBUTION OF NIPA SWAMPS.

THE USE OF SULPHUR FUMES IN COPRA DRYING[1]

By A. H. WELLS

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and

G. A. PERKINS

Chemist, Bureau of Science, Manila

TWO PLATES

A few years ago almost any grade of copra or coconut oil was salable at a good price. To-day a "Manila" oil of high rancidity and color finds a poor reception in the markets of the world. The Philippine oil mills are faced on one hand with a demand for high-grade oil, and on the other with a low-grade supply of copra from which good oil cannot possibly be made except at a prohibitive cost. This situation is thought by many to require the "cure-all" of legislation, but the writers favor the use of other methods to improve the quality of Philippine copra. The application of sound business principles to the oil and copra industries would solve the difficulty.

The main cause of color and free fatty acid in coconut oil is the action of mold on the copra. Any method, therefore, of drying coconut meat that protects it from mold and contamination with dirt and smoke makes possible the production of good oil. The most economical method of drying for very large plantations, and at the same time one which produces excellent copra, is by steam, using modern machinery. The economy of this method is that it saves labor, which is a very important item on large holdings. On smaller plantations, such as are found generally throughout the Philippines, the initial cost and overhead expenses of steam dryers are large items compared with the labor that they save.

The problem of how to dry copra on large plantations has been rather satisfactorily handled by the firms that manufacture drying machines, some of which have agencies in Manila. Therefore, the problem of the small plantation has occupied the

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[1] Received for publication January 28, 1922.

attention of the Bureau of Science, and the use of sulphur has been found well suited to this field.

The process of sulphuring copra has been described and its advantages have been pointed out by Brill, Parker, and Yates.[2] The purpose of the present paper is to record certain modifications that have been found advisable during several years of successful commercial use of the process in the Philippines.

THE SULPHURING BOX

One form of sulphuring apparatus is shown in Plate 1, fig. 1. A slightly different type is shown in Plate 1, fig. 2, and Plate 2, fig. 3. The details of construction of this apparatus, which was made by Mr. H. J. Detrick, at Polo Plantation, Dumaguete, are as follows:

The sulphuring box, inside measurements 120 centimeters (4 feet) wide, 265 centimeters (8 feet, 10 inches) long, 210 centimeters (7 feet) high, was constructed of tongue-and-groove lumbayao, 2.5 centimeters (1 inch) thick. Eight uprights 5 by 10 centimeters (2 by 4 inches) were employed. It was erected in a shed with galvanized iron roof and dirt floor.

One length, about 5 meters (17 feet), of 60-centimeter (24-inch) cane track, and two pairs of wheels, with rough boxings, were purchased from a sugar hacienda at Bais. A frame of 5-by-10-centimeter (2-by-4-inch) and 5-by-15-centimeter (2-by-6-inch) pieces was fitted over the wheels. The track was laid in a ditch 20 centimeters (8 inches) deep.

Sixteen trays, outside measurements 90 by 230 by 10 centimeters (3 feet by 7 feet 8 inches by 4 inches), were constructed of malatabigi about 3 centimeters (1⅛ inches) thick. The bottoms were made of bamboo strips about 6 centimeters (2.5 inches) wide, leaving a maximum opening of 1.3 centimeters (0.5 inch). This floor rested at the ends and at three places between the ends on horizontally laid 5-centimeter (2-inch) strips. The whole was strengthened by nailing above the bamboo directly over each of the crosspieces, except the central one, a strip of 6-by-3-centimeter (2½-by-1⅛-inch) malatabigi. This construction produced strong ends made up of three pieces, one 10 centimeters (4 inches), one 6 centimeters (2.5 inches), and one 5 centimeters (2 inches). The 6-centimeter (2.5-inch) pieces were laid upright, like floor joists (see Plate 2, fig. 3).

The capacity of this box was 3,000 nuts (without shells).

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[2] Brill, H. C., Parker, H. O., and Yates, H. S., Copra and coconut oil, Philip. Journ. Sci. § A 12 (1917) 80.

Cost of constructing the sulphuring box.

	Pesos.
Wheels and track, second hand	20.00
2-by-4-inch lumber, 80 feet at 0.125 peso	10.00
Tongue-and-groove lumbayao, 252 feet at 0.16 peso	40.32
1⅛-inch malatabigi, 260 feet at 0.148 peso	38.48
Bamboos, 25 at 0.15 peso	3.75
Nails, 7 kilograms at 0.70 peso	4.90
Labor	14.40
Transportation, approximate	20.00
Total	151.85

Sulphur burner.—The sulphur is burned in a pan placed on the dirt floor of the box. To utilize crude native sulphur a flat pan, made from a kerosene can, was devised by Mr. Detrick. The top and the bottom were removed, and the sides flattened out in one piece. The edges were then bent up to form a tray 22 by 75 centimeters.

The amount of sulphur to be used depends on the rainfall and conditions of drying. One kilogram for each charge is usually sufficient, and requires about four hours in burning. Pure sulphur is sold in Manila drug stores for 0.30 peso per kilogram, but the crude variety found in Silay, Occidental Negros; Biliran, Leyte; Camiguin, Misamis; Camiguin, Cagayan; and other parts of the Philippines is also suitable for this use.

PREPARATION OF THE NUTS

The nuts can be sulphured before removal of the shells, but it is better to sun them, if possible, for an hour or so after opening (see Plate 2, fig. 4); then the meat is separated from the shell with a copra knife, and placed on the sulphuring trays. The preliminary sunning shortens the work by loosening the meat. In case the trays are made with solid sides and placed directly on each other with no air space between they are staggered, as shown in Plate 1, fig. 1, in order to allow circulation of the sulphur fumes. Loading the high pile of trays on the truck is facilitated by digging a shallow ditch for the track, as shown in this photograph.

The loaded truck is rolled into the box, a match applied to the sulphur, and the door closed tightly. If 1 kilogram of sulphur is used, six hours in the box is sufficient for the full effect of the fumes. Larger charges necessitate somewhat more time, or the entrance of a little air at the bottom may be permitted, to burn the sulphur more rapidly.

DRYING

The use of sulphur has been expected by some to dry the copra. This is not the case, but sulphured coconut meat can be dried in a shed without sunshine, if necessary. Plate 2, fig. 2, shows sundried copra which had been placed in the bodega several times on account of rain. One *amacan* in the left foreground shows plainly the ravages of mold under those conditions on copra which has not been sulphured. The clean white copra on the other amacans in the foreground was treated in exactly the same way except that it was sulphured soon after opening. One and one-half kilograms of sulphur per charge of 2,500 nuts has been used in this case.

In regions where the rainy season is severe, drying sheds can be constructed in which trays of copra can be stacked with air space above every tray for ventilation. In such a shed sulphured copra can be dried in two or three weeks without sunshine. In regions where the rain is less severe the expense of shed construction can be avoided by sundrying on a floor, amacans, or trays. At Polo Plantation it has been found most satisfactory to spread the coconut meat thinly on light trays, which are easily stacked and covered with a small nipa roof at night or in case of rain (see Plate 2, fig. 1). The time required for drying is four days or more, depending on the weather.

NATURE OF THE PRODUCT

Sulphured copra, properly dried, has a lighter appearance than the whitest sundried copra, because the sulphur partially bleaches the dark outer skin of the meat as well as preserves the natural whiteness of the inside surface. The moisture content is about 5 per cent, and the free fatty acid less than 1 per cent.

The sulphur dioxide partly evaporates from the copra during drying, and partly oxidizes to sulphuric acid. The sulphuric acid formed does not remain in the oil, or injure it in any way, It does remain in the press cake, however. For this reason, and because there is sometimes difficulty in expressing all of the oil from very highly sulphured copra, it is better to sulphur lightly when possible. It has been found that when about a kilogram of sulphur per 3,000 nuts is used, on an average, the protection against mold is ample and no trouble is met with in expressing the oil or in using the cake for animal feed. The cake produced is, in fact, superior to the ordinary grade of cake made from rancid, moldy copra.

The direct protection afforded by sulphur dioxide does not last more than a month, but it is well known that copra is not susceptible to mold if once thoroughly dried and kept in a reasonably dry place. Copra beetles, unless checked, will eventually attack any copra and rapidly destroy copra that has become moldy. They are not attracted, however, by sound copra, so that the prevention of mold by sulphuring also prevents spoilage by beetles, for a number of months, at least.

WHEN TO USE SULPHUR

Sulphuring should be done soon after the nuts are opened, if rainy weather is anticipated. If unsulphured copra is rained on unexpectedly, it can be sulphured even after mold has started. The mold, or insects, can always be killed, and immediate further damage prevented, but it is advantageous to sulphur as soon as possible to prevent damage and loss of oil.

Sulphuring is valuable chiefly as an adjunct to the sundrying process. It is not necessary if a rapidly acting hot-air dryer is used, but can be employed to supplement hot-air drying in homemade kilns. It is also of value to the copra trader, who is often obliged to redry low-grade copra, and to kill the insects and the mold that otherwise soon complete its destruction.

ILLUSTRATIONS

PLATE 1

FIG. 1. Sulphuring box with sixteen trays, containing the meat from about 3,000 nuts.

2. Sulphuring box with nine trays. These nuts (1,200) are to be sulphured before removing the shells.

PLATE 2

FIG. 1. Stacks of sulphured copra ready for rain. Courtesy of Mr. Detrick.

2. Copra, sulphured and not sulphured. The amacan in the left foreground shows the best grade of copra that could be produced at that time without the use of sulphur.

3. Suphuring trays. The drying trays are made lighter than these.

4. Opening nuts at Polo Plantation. This lot of over 50,000 nuts was subsequently sulphured in the box shown in Plate 1, fig. 1. Courtesy of Mr. Detrick.

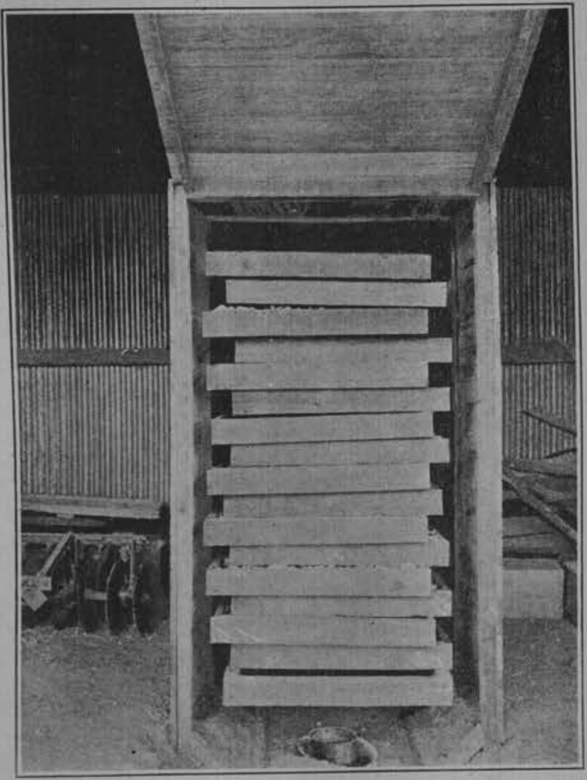

Fig. 1. Sulphuring box with sixteen trays.

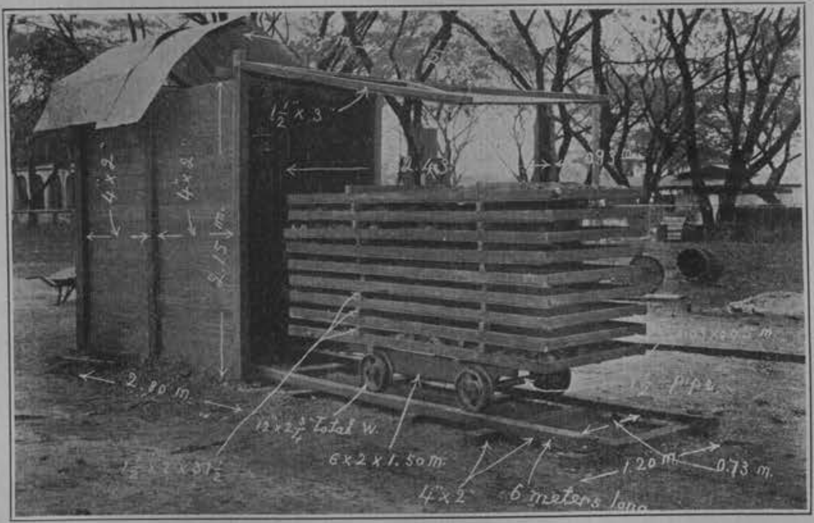

Fig. 2. Sulphuring box with nine trays.

PLATE 1.

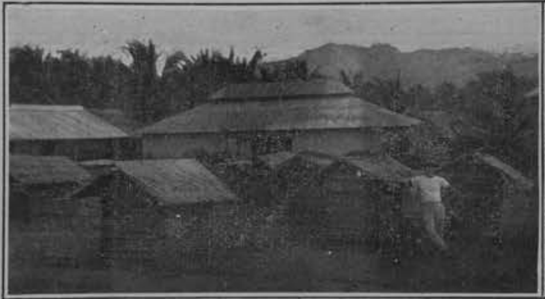

Fig. 1.

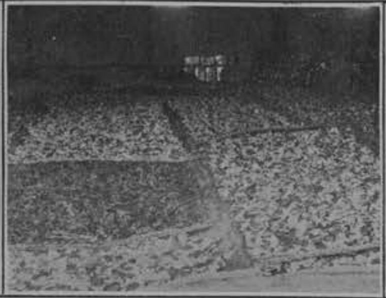

Fig. 2.

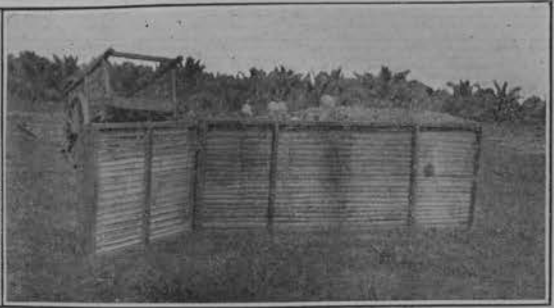

Fig. 3.

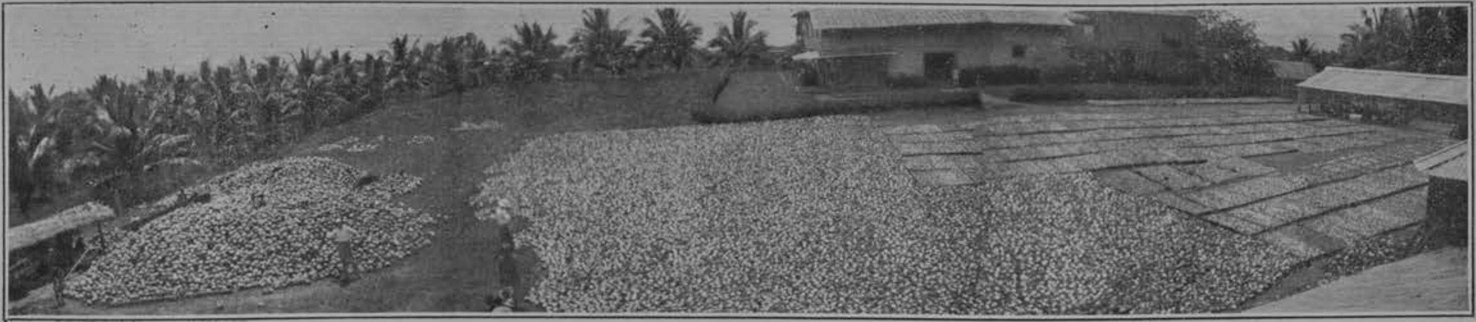

Fig. 4. Opening nuts at Polo Plantation.

PLATE 2.

HISPINEN DER ALTEN WELT

Von J. WEISE
Herischdorf i. Riesengebirge, Germany

Eine Sendung von Herrn Donckier in Paris und von Herrn T. C. Moulton aus dem Sarawak Museum, sowie die Ausbeute welche Herr Drescher in neuester Zeit auf Java machte und an meinen Collegen Herrn Reineck in Berlin schickte, lieferten hauptsächlich den Stoff zu den folgenden Beschreibungen und Anmerkungen. Auch zwei sehr hübsche Arten von den Philippinen konnte ich einfügen.

Botryonopa grandis Baly.

Das Weibchen, 26 Millimeter lang, hat eine einfache Hinterbrust und vor dem abgestutzten Hinterrande des letzten Abdominalsegmentes eine sehr grosse Grube, die doppelt so breit wie lang und einem Kreisabschnitte ähnlich geformt ist, während das kleinere Männchen im vorderen Teile der Hinterbrust zwei nebeneinander liegende Zähnchen und im Hinterrande des letzten leicht gewölbten Bauchsegmentes eine schwache Ausrandung besitzt.

Anisodera modesta sp. nov.

Supra brunneo-rufa, subtus rufo-picea, antennis saepe nigris, articulis quinque basalibus supra, quatuor subtus subglabris, nitidis, prothorace latitudine longiore antrorsum leniter angustato, disco sat crebre punctato, elytris nitidulis fortiter et regulariter striato-punctatis, tenuissime costatis, apice leviter emarginatis.

Long., 13 ad 15 mm.

Borneo, Matang, April, 1902, 3200 F.; Kuching, September 19, 1899; Rook Road, August 9, 1909; Mount Saribu, Mai, 1902 (Museum Sarawak).

Mit *A. sheppardi* am nächsten verwandt, durchschnittlich kleiner als diese und bedeutend schlanker, die Fühler etwas dünner und ihre ersten fünf Glieder an der Spitze nicht knotig verdickt, die Flügeldecken ganz ähnlich stark, aber regelmässiger punktirt, mit kleinerer Spitzenausrandung, die Rippen viel feiner und die erste nie vor der Mitte ausgebildet.

Schlank gebaut und mässig gewölbt, oben dunkel bräunlich rot, unten pechbraun oder schwarz, ähnlich auch die Fühler gefärbt, Schildchen schwarz, die Nahtkante der Flügeldecken dahinter ein kurzes Stück angedunkelt. Stirn ziemlich schmal, matt, zur Mittelrinne abfallend. Halsschild um ein Drittel länger wie breit, cylindrisch, matt, die Seiten ziemlich parallel, vorn leicht convergirend, die Scheibe ziemlich dicht und kräftig punktirt, die Mittellinie vor der Mitte glatt und in der Regel erhöht und glänzend. Flügeldecken schwach glänzend, stark in regelmässigen Reihen punktirt, nur die fünfte und sechste (ganze) Reihe hinter der Mitte durch einige dazwischen tretende Punkte leicht gestört; die Rippen sind scharf, aber fein, die erste ist nur im letzten Drittel oder Viertel vorhanden und schwächer wie die übrigen, die zweite und dritte sind normal.

Anisodera integra sp. nov.

Supra opaca, antennis, scutello corporeque subtus piceis, antennis articulis quinque supra, quatuor subtus subglabris, nitidis, prothorace longiore quam lato, utrinque leniter angustato, crebre punctato, cum capite obscure ferrugineo, elytris dilute flavo-testaceis, subtiliter striato-punctatis, apice communiter rotundatis, haud emarginatis, dorso tenuiter costatis, costa prima medio longe interrupta.

Long., 13 mm.

Borneo, Kuching, Mai, 1900 (Museum Sarawak).

Der vorigen ähnlich, die Flügeldecken jedoch heller gefärbt wie der Vorderkörper, matt, das Halsschild etwas dichter, die Flügeldecken feiner und flacher punktirt und an der Spitze schmal gemeinschaftlich abgerundet, ohne Ausschnitt.

Unterseite, Fühler, und Schildchen pechschwarz, Kopf und Thorax dunkel rotbraun, Flügeldecken blass rötlich gelbbraun. Fühler kräftig, die ersten fünf Glieder cylindrisch, oben fast glatt, glänzend, unten Glied 5 eben so dicht wie die folgenden behaart. Stirn schmal, zur Mittelrinne abfallend. Halsschild um ein Viertel länger als breit, beiderseits leicht verengt, dicht punktirt, ein kleiner gerundeter Raum der Mittellinie vor der Mitte glatt. Flügeldecken fein und wenig tief gereiht-punktirt, die Rippen schmal und ziemlich scharf, die erste ungefähr von ein bis drei Viertel der Länge unterbrochen, die zweite im ersten Viertel erloschen, die Schulterrippe ganz.

Anisodera marginella sp. nov.

Nigra vel picea, fronte, prothorace (lateribus exceptis) elytrisque ferrugineis; antennis articulis quinque supra, tribus subtus subglabris, nitidis, prothorace longiore quam lato, subcylindrico, sat crebre punctato, elytris sat subtiliter striato-punctatis, apice parum emarginatis, limbo angusto laterali postice abbreviato nigro.

Long., 12 ad 15 mm.

Matang, Februar 14, 1900; Sior, Juni 1, 1910 (Museum Sarawak).

Wie *A. modesta* gebaut, aber das Halsschild noch etwas länger, die Flügeldecken feiner und hinten verworrener punktirt, ohne recht deutliche Rippen, an der Spitze mit einer sehr kleinen, jedoch etwas tieferen Ausrandung und auf der Unterseite der Fühler nur drei Glieder glänzend; *A. testacea* Gestro hat einen viel kürzeren Thorax.

Schwarz bis rötlich pechbraun, Stirn, Thorax, und Flügeldecken blass rostrot, ein schmaler Seitensaum des Halsschildes und der Flügeldecken (auf diesen hinten mehr oder weniger abgekürzt) schwarz. Stirn zwischen den Augen sehr schmal, Thorax etwas mehr als um ein Drittel länger wie breit, cylindrisch, vor und hinter der Mitte unbedeutend ausgerandet, ziemlich dicht punktirt, matt. Flügeldecken wenig glänzend, fein gereiht-punktirt, die Reihen hinter der Mitte meist sehr verworren; von den Rippen ist nur die zweite in den hinteren zwei Dritteln angedeutet, ausserdem sind vor der Spitze kurze Stücke der übrigen zu bemerken.

Anisodera sinuata sp. nov.

Testacea vel obscure ferruginea, subtus obscurior, antennis (saepe), scutello pedibusque nigris, illis articulis primis quatuor supra, tribus subtus subglabris, nitidis, prothorace longiore quam lato, subcylindrico, minus crebre punctato, basi late depresso, elytris sat subtiliter striato-punctatis, obsolete bicostulatis, apice rotundatim-emarginatis.

Long., 9 ad 13 mm.

Matang, December 29, 1909; Januar 7 und Mai 31, 1910. (Museum Sarawak).

Eine der kleineren Arten; durch die Fühler, an denen die vier Basalglieder oben und drei unten fast kahl und glänzend sind, das lange Halsschild, und die verhältnismässig fein punktirten Flügeldecken zu erkennen, welche in der Spitze einen bogenförmigen Ausschnitt besitzen, der merklich länger wie der von *A. sheppardi* ist. Von den primären Rippen ist die zweite schmal, niedrig, aber deutlich zu erkennen, während die dritte noch schwächer ist und wenig in die Augen fällt. Der Penis bildet eine schwach gekrümmte und von oben leicht zusammengedrückte Röhre, welche etwa so lang wie der Bauch und von der Basis aus allmählich bis vor die Mitte der Oeffnung leicht erweitert ist, dann verengt sie schnell, gerundet, in eine breite, aufgebogene, wenig vortretende Spitze.

Die Gattung *Anisodera* s. str. hat eine eigene Skulptur der Flügeldecken, die aus 10.5 Punktreihen und 3 primären Rippen besteht. Die erste Rippe, die von der Naht durch die abgekürzte Punktreihe am Schildchen und die beiden ersten ganzen Reihen getrennt wird, ist ganz, zum Beispiel bei *A. guerini*, oder in der Mitte unterbrochen (*A. lucidiventris*), bei vielen Arten nur im letzten Drittel bemerkbar, selten völlig geschwunden; die zweite liegt normal, zwischen der vierten und fünften ganzen Punktreihe und ist nur in einigen Arten (*A. scutellata, A. guerini*) ganz, sonst vorn abgekürzt; die dritte liegt vorn normal zwischen der sechsten und siebenten Punktreihe, biegt in etwa ein Drittel der Länge etwas nach aussen und wird secundär, da sie die siebente und achte Punktreihe bis zur Spitze trennt. Auf dem hinteren Abfalle der Flügeldecken bildet sich bei vielen Arten jedoch neben ihr noch ein kurzes Stück der dritten primären Rippe aus. Von den ersten Fühlergliedern sind an der Spitze knotig verdickt: Glied 1 bis 5 bei *A. sheppardi,* 2 bis 5 bei *A. sculpticollis,* 3 bis 5 bei *A. whitei* und 3 bis 6 bei *A. scutellata.* Nach den Beschreibungen könnten vielleicht folgende, im Cataloge von mir unter *Lissochila* aufgeführte Arten zu *Lassiochila* gehören: *humilis, nasuelli, propinqua,* und *testacea.*

Genus **DRESCHERIA** novum

Corpus valde elongatum, subparallelum, depressiusculum. Antennae sat breves, 11-articulatae, articulis 5 ultimis dilatatis. Frons inter antennas in cornum subquadratum producta. Prothorax subquadratus, pone medium leviter angustatus. Elytra prothorace vix latiora et plus quam quintuplo longiora, apice angustata et subtruncata, angulo suturali dentiformi instructa, dorso in seriebus 8.5 punctato striata, subtiliter tricarinulata, carinis internis antice longe deficientibus. Pedes breves.

Diese Gattung gehört in die Gruppe der Cryptonychinen zwischen *Octodonta* und *Bronthispa* und unterscheidet sich von den verwandten Gattungen durch die Flügeldecken, welche nicht

10.5, sondern 8.5 Punktreihen und 3 zarte Rippen besitzen, von denen die beiden inneren nur nahe der Spitze vorhanden sind. Die Stirn ist viereckig, etwas breiter als lang, eben, jederseits von einer Augenleiste begrenzt, vorn schnell zu einem halb so breiten, mässig langen Fortsatze verengt, welcher fast quadratisch und oben concav ist. Der Clypeus ist gross, lang, annähernd rechteckig, aber nach oben etwas verschmälert, abgeflacht, mit einer niedrigen, stumpfen Mittelleiste, fein runzelig punktirt und dicht aufstehend behaart. Die Fühler sind kurz und reichen kaum bis zur Basis der Flügeldecken, Glied 1 dick, keulenförmig, 2 halb so lang und dick, 3 kleiner als 2, etwas länger wie eins der drei folgenden Glieder, die fünf Endglieder sind erweitert, etwas zusammengedrückt, jedes wenig breiter und etwa so lang als 2, das letzte Glied eine Spur länger, mit verrundeter Spitze. Der Thorax hat ungefähr die Form wie bei einer *Downesia*, er ist etwa so lang als breit, mit abgerundeten Vorder- und rechtwinkeligen Hinterecken, an den Seiten unbedeutend nach hinten verengt und dicht hinter der Mitte sanft ausgebuchtet, auf dem Rücken schwach querüber gewölbt. Flügeldecken in den Schultern so breit wie der Thorax am Vorderrande, in ein Drittel der Länge wenig eingeschnürt, dann ziemlich parallel, im letzten Viertel sanft verengt und an der Spitze gerundet-abgestutzt, mit vortretender Nahtecke; auf dem Rücken abgeflacht. Beine kräftig und sehr kurz, das vierte Tarsenglied kaum länger wie die Lappen des dritten Gliedes, Klauen einfach, gegenständig.

Ich nenne die Gattung nach Herrn Drescher, der in den letzten Jahren mit ausgezeichnetem Erfolge auf Java gesammelt hat.

Drescheria reinecki sp. nov.

Nigra, nitida, fronte subtiliter ruguloso-punctata, prothorace substrigoso-punctulato, linea media lata sublaevi, elytris subtiliter striato-punctatis.

Long., 6 ad 7; lat. 1 ad 1.2 mm.

Java, Mount Merbabu, Mai, 1912 (*Drescher*).

Sehr langgestreckt, abgeflacht, glänzend schwarz. Stirn dicht und fein runzelig-punktirt, nur der Fortsatz oben glatt. Thorax auf einem breiten Mittelstreifen weitläufig mit äusserst feinen Punkten besetzt, fast glatt, an den Seiten mässig dicht punktulirt und vor der Mitte längsgestrichelt. Flügeldecken mit 8.5 feinen Punktreihen, die in flachen und feinen, erst hinter der Mitte tieferen Streifen stehen. Die dritte primäre Rippe ist fein und niedrig, ganz, die beiden anderen sind kräftiger, aber nur im letzten Viertel vorhanden, auch die Naht is hinter der Mitte erhöht.

Bronthispa javana sp. nov.

Valde elongata, depressiuscula, flavo-ferruginea, nitida, antennis piceo-nigris, fronte ruguloso-punctata, prothorace subquadrato, crebre punctato, carinula obsoleta, utrinque medioque postico disci sublaevibus, elytris striato-punctatis (seriebus 5 ad 8 ante medium et seriebus 3 ad 6 juxta apicem series duas formantibus), apice bicarinatis, truncatis.

Long., 9 mm.

Java, Samarang (*Drescher*).

Der mir unbekannten *B. longissima* von der Aru-Insel Wokan nahe verwandt, die Erweiterung der Thoraxseiten hinter dem Vorderrande ziemlich breit abgerundet und die Spitze der Flügeldecken gradlinig abgestutzt.

Sehr lang gestreckt, abgeflacht, gelblich rostrot, glänzend, die Flügeldecken etwas dunkler, mit einem kaum merklichen bläulichen Anfluge versehen; Fühler pechschwarz, Glied 1 lang und dick, fast cylindrich, 2 das kleinste, wenig länger als breit, 3 etwas länger wie 2, beide zusammen kürzer als Glied 1, die drei folgenden Glieder unter sich ziemlich gleich, jedes länger als 3, von den fünf breiteren, leicht zusammengedrückten Endgliedern ist Glied 7 länger als eins der folgenden und an der Innenseite, die übrigen gänzlich, dicht, äusserst kurz, und fein behaart. Stirn quadratisch, abgeflacht, dicht und etwas runzelig punktirt, mit feiner Mittelrinne, die auf den schmalen, stabförmigen, vorn abgestutzten Fortsatz übergeht. Kopfschild lang, dicht abstehend gelblich behaart. Thorax etwas länger als breit, mit convexem Vorderrande vor den Hinterecken, die durch einen Einschnitt dornförmig abgesondert sind, zunächst leicht erweitert, dann bis zum ersten Drittel schwach verengt, hierauf in einen abgerundeten Vorsprung erweitert, der vorn fast gradlinig verschmälert ist. Auf dem Vorsprunge liegt eine niedrige, verloschene und schräg nach innen und hinten ziehende Leiste, welche nebst einem Raume vor dem Schildchen glatt erscheint. aber unter stärkerer Vergrösserung zart punktulirt ist; die übrigen Teile sind dicht punktirt. Die Punktreihen der Flügeldecken sind regelmässig, aber die dritte bis sechste Reihe hinten, die fünfte bis achte vor der Mitte auf zwei Reihen beschränkt. Auf dem Abfalle zur Spitze sind ausser der erhöhten Naht noch die beiden ersten primären Rippen deutlich ausgeprägt und die Spitze ist von der ersten Rippe der einen Decke bis zu der der andern abgestutzt. Die Zwischenstreifen sind äusserst fein punktulirt.

Xiphispa obligata sp. nov.

Elongata, dilute rufo-testacea, supra subopaca, capite antennisque obscurioribus, elytris nigris. Prothorace sat crebre punctato lateribus pone apicem angulatis, elytris crebre striatopunctatis, carinulis primariis subtilissimis, sat obsoletis, tertia antice longe abbreviata.

Long., 7 mm.

Java, Salatiga.

Die vorliegende Art bildet das bisher unbekannte Bindeglied zwischen den Arten von Neu-Guinea und Madagascar; sie erinnert in der Färbung am meisten an *X. meijerei.* Der Körper ist langgestreckt, wenig gewölbt, rötlich gelbbraun, oberseits fast matt, Flügeldecken schwarz, Kopf und Fühler dunkel rostrot, die Spitze der letzteren und der Hals schwärzlich. Fühler schlank, alle Glieder deutlich getrennt, die fünf fast kahlen Endglieder nur unbedeutend stärker als die vorhergehenden, so dass die Art zu *Xiphispa* i. sp. gestellt werden muss. Stirn quadratisch, eben, dicht runzelig punktirt, mit einer Mittelrinne, die sich auf das schmale, stäbchenförmige, vorn abzestutzte Kopfhorn verlängert. Thorax etwas länger als breit, ziemlich dicht punktirt, die Seiten hinten fast parallel, vor der Mitte in einen kleinen stumpfwinkeligen Zahn erweitert, davor convergirend, die Vorderecken in Form eines sehr kurzen Kegels vortretrend. Schildchen glatt. Flügeldecken in den stumpfwinkeligen Schultern merklich breiter wie das Halsschild, sodann ziemlich von gleicher Breite, nur hinter der Schulter leicht eingezogen, am Ende gemeinschaftlich abgerundet; dicht und ziemlich stark in regelmässigen Reihen punktirt. Zwischenstreifen sehr schmal, die graden wenig höher wie die ungraden und feine Leisten bildend, von denen die dritte vor der Mitte fehlt, weil die Punktreihen 5 bis 8 daselbt auf zwei verringert sind.

Prionispa magnifica sp. nov.

Cuneiformis, subtus ferruginea, femoribus, tibiis antennisque pallide flavis, his articulis quatuor ultimis nigris, supra metallicoviridis, elytris flavo et cupreo marginatis, angulo postico extremo lobatis, dorso carina prima pone medium, secunda medio cupreis instructis.

Long., 3.5 mm.

Luzon, Mount Maquiling (*Baker*).

Kleiner als *P. gemmata* und *P. pulchra*, der hintere Aussenwinkel der Flügeldecken nicht zugespitzt oder dornförmig wie bei diesen, sondern in einen schräg nach aussen und hinten gerichteten dreieckigen, an der Spitze breit abgerundeten Lappen erweitert; von *P. vethi* durch helle Fühlerfarbe und die hinter der Mitte der Flügeldecken fehlenden Höcker, von *P. longicornis* endlich durch die sehr abweichende Skulptur der Flügeldecken verschieden.

Die Unterseite ist glänzend bräunlich rostrot, der Bauch heller; Schenkel, Schienen, und Fühler blassgelb, die vier Endglieder der letzteren tief schwarz. Die Oberseite ist glänzend und lebhaft metallisch grün, Stirn und Thorax goldgelb überflogen, ein breiter Seiten- und Hinterrandsaum der Flügeldecken blassgelb, innen bräunlich-kupferig angehaucht, ebenso der Ecklappen jeder Flügeldecke und der vorhandene Rest der beiden ersten Rippen. Die erste ist ungefähr im vierten Fünftel der Länge, die zweite im mittleren Drittel ausgeprägt. Stirn sparsam punktirt, vorn in einen dreieckigen Zipfel ausgezogen. Drittes Fühlerglied nur etwas länger als eins der beiden ersten Glieder. Thorax dicht und stark punktirt, in der Mittellinie glatt. Die Punkte in den Reihen der Flügeldecken sind denen des Halsschildes ähnlich, die der letzten Reihe aber stärker.

Javeta moultoni sp. nov.

Elongata, nigra, fronte prothorace apice femoribusque posticis brunneo-rufis. Prothorace foveis septem parce punctatis (anterioribus pubescentibus), elytris fortiter striato-punctatis, tricostulatis.

Long. vix 5 mm.

Borneo, Sarawak, Baram, November 10, 1910 (Museum Sarawak).

Schwarz, mässig glänzend, Oberlippe rotgelb, die Stirn bräunlich rot, ähnlich, doch dunkler, auch das Halsschild nach der Basis hin und die Hinterschenkel; die vier ersten Bauchsegmente am Hinterrande fein gelblich gesäumt. Stirn spiegelglatt, Thorax kaum so lang als breit, an den Seiten sehr wenig gerundet und vorn undeutlich, hinter der Mitte merklicher eingeschnürt, oben gewölbt aber sehr uneben; das erste Drittel wird von einem etwas niedergedrückten, in der Mitte sparsam und grob punktirten, nach den Seiten hin dicht punktulirten und dicht kurz und fein aufstehend behaarten[1] Querstreifen eingenommen, welcher nahe dem Rande in eine tiefe Grube übergeht. Hinter dieser befindet sich je eine ähnliche aber kahle Grube, beide stark punktirt. Im mittleren Teile der Scheibe liegen drei kleinere, mit wenigen groben Punkten besetzte Gruben, zwei am Basalrande dicht neben einander und eine davor. Die Flügeldecken sind fast parallel, hinter der Mitte wenig verbreitert, auf dem Rücken in regelmässigen, leicht vertieften Reihen stark und sehr dicht punktirt. Die drei secundären Rippen liegen normal (die erste zwischen der dritten und vierten Punktreihe) und sind deutlich, wenn auch nicht besonders stark, nur die dritte ist sehr schmal und fein.

Diese Art erlaube ich mir nach dem Curator des Sarawak Museums Herrn J. C. Moulton zu benennen.

Coelaenomenodera cucullata Guer. ist nach der Fühlerbildung eine *Balyana*, denn die vier Endglieder bilden einen dicht behaarten matten Cylinder, an welchem die Nähte nur leicht angedeutet sind. Die ersten sieben Glieder sind getrennt, sparsamer behaart, und mässig glänzend. Glied 1 ist kurz, dick, 2 wenig kürzer aber dünner, 3 schlank, doppelt so lang als 2 und von allen das längste, 4 merklich kürzer, 5 wenig kürzer wie 4, 6 dem zweiten ähnlich, 7 so lang als 5 aber nach der Spitze verdickt und hier so breit als das Endglied. Der Körper ist 9 bis 10.5 Millimeter lang, glänzend rotgelb, die Tarsen angedunkelt und das zusammengesetzte Endglied der Fühler schwarz. Thorax länger als breit, grob punktirt, nur die Zwischenwände der sechs Gruben (2, 2, 2) glatt und stark glänzend. Die beiden ersten Gruben (auf der über den Kopf vorgezogenen und vorn abgerundeten Kapuze) sind gross, sehr tief, lang eiförmig, die folgenden vier flach und viel kleiner, quer. Flügeldecken grob punktirt-gestreift, die Intervalle bilden feine Leisten, von denen die dritte, fünfte, und siebente nur unbedeutend stärker als die andern sind.

Coelaenomenodera cucullata var. fuscicornis var. nov.

Ueber das variiren der *Coelaenomenodera* ist aus Mangel an Material zur Zeit wenig bekannt und ich kann hier auch nur zwei Fälle anführen. Im Hamburger Museum steckt ein Exemplar mit der allgemeinen Fundortsangabe Madagaskar

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[1] Die Behaarung der vorderen Thoraxgruben von mir bereits Arch. f. Naturgesch. (1905) 98 erwähnt, scheint der Gattung *Javeta* wirklich eigentümlich zu sein.

(*Kiderlen*), welches ich noch zu *C. cucullata* rechne, obwohl an den Fühlern die beiden ersten Glieder allein bräunlich rot, die folgenden (ausser dem tief schwarzen zusammengesetzten Endgliede) pechbraun sind. Auch die Kapuze ist vorn nicht gleichmässig abgerundet, sondern gerundet-abgestutzt. Ich bezeichne dies Tier als var. *fuscicornis*.

Sodann besitze ich ein Stück aus Madagaskar (*Staudinger*) von *Balyana armata* Gestro, welches in folgenden Punkten von der Beschreibung der einzigen Type abweicht: Die Fühler sind nicht 9- sondern regelrecht 8-gliedrig, Glied 1 bis 3 unter sich an Länge gleich, 4 bis 6 jedes eine Spur kürzer, 7 dagegen um die Hälfte länger, nach oben verbreitert und an der Spitze auch um die Hälfte breiter als 6, das zusammengesetzte achte Glied ist wenig dicker als 7 und so lang wie Glied 6 und 7 zusammen, am Ende mässig scharf zugespitzt. Die Flügeldecken haben an der hinteren Aussenecke keinen spitzen, nach hinten gestreckten Zahn, sondern eine stumpfwinkelige Ecke, welche durch die plötzliche Verengung des abgesetzten Seitenrandes entstanden ist. Dieses Stück dürfte das andere Geschlecht von *B. armata* sein, eine Art, welche von den übrigen durch die nur von einer Grube eingenommenen Kapuze abweicht.

Coelaenomenodera suturalis Guer.

Die schwarze Mittelbinde des Thorax nimmt an der Basis mehr als das mittlere Drittel der Breite ein, ist davor plötzlich stark verengt und endet in einer Spitze, die weit vom Vorderrande entfernt bleibt.

Madagaskar, Maroantsetra (*Staudinger*).

Coelaenomenodera funerea sp. nov.

Elongata, subtus nigra, supra atra, prothorace crebre et fortiter subrugoso-punctato, cucullo subtriangulari lineisque tribus obsoletis nitidis, elytris valde striato-punctatis, transversim plicatis, tricarinulatis.

Long., 11 mm.

Madagaskar, Tananarive.

Der *C. distinguenda* Fairm. sehr nahe stehend und vielleicht nur eine einfarbig schwarze Form derselben, aber die Fühler etwas länger wie die von *C. femorata* und die dritte (secundäre) Rippe der Flügeldecken hinten kaum schwächer wie die beiden inneren.

Die Fühler reichen bis an die Basis der Flügeldecken und sind ziemlich dick, Glied 1 und 2 klein, sparsam behaart, glänzend, die folgenden länger und breiter, matt, 3 bis 5 an den Seiten deutlich länger behaart als die folgenden, Glied 8 bis 10 etwas kürzer wie die vorhergehenden und allmählich verdünnt, nur durch eine leichte Einschnürung getrennt, das Endglied stumpf zugespitzt. Scheitel glatt, durch eine unregelmässig verdoppelte, starke punktreihe von der Stirn geschieden; auf dieser laufen zwei parallele Längsleisten nach vorn bis zwischen die Fühler und schliessen einen dicht punktirten und grau behaarten Streifen ein. Thorax von der Basis bis vor die Mitte allmählich schwach verengt, davor wieder erweitert, hinter den höckerartig heraustretenden Vorderrande ausgeschnitten, letzterer kapuzenförmig weit über den Kopf vorgezogen, glänzend, und mit zwei lang eiförmigen Gruben besetzt. Der übrige teil der Scheibe ist grob, sehr dicht punktirt, und hat drei feine, unregelmässige, glatte Längslinien. Flügeldecken bedeutend schlanker wie die von *C. femorata*, mit dicht nebeneinander stehenden Reihen von grossen und tiefen viereckigen, durch eine Querleiste getrennten Punkten und drei ziemlich schmalen Längsrippen. Die zweite geht vorn, nahe der Basis, in eine Punktreihe über, die dritte ist vor der Mitte niedriger wie hinter derselben.

Das einzige Stück befindet sich in der Sammlung von Herrn Donckier.

Coelaenomenodera donckieri sp. nov.

Elongata, parallela, rubra, nitida, antennis fulvis, articulis quinque ultimis dilatatis, clavam formantibus, articulis tribus apicalibus nigris; prothorace subpolito, basi impresso, cucullo magno, fere semicirculari, foveis duabus magnis, punctatis impresso, elytris striato-punctatis.

Long., 4 ad 4.5 mm.

Madagaskar, Tananarive, Mahatsinjo (*Donckier, Staudinger*).

In Grösse und Farbe der *C. coccinea* am ähnlichsten, aber von ihr und den anderen roten Arten durch die fehlenden Rippen der Flügeldecken und die grosse, ziemlich halbkreisförmige Kapuze welche die vordere Hälfte des Thorax bildet und weit über den Kopf reicht, auf den ersten Blick zu unterscheiden.

Gestreckt und parallel, lebhaft glänzend rot, Fühler rötlich gelb, ihre drei Endglieder und oft noch die Spitze des achten Gliedes schwarz, die ersten sechs Glieder ziemlich kräftig, Glied 2 etwas länger als eins der übrigen, 7 mässig, die folgenden etwas stärker erweitert, das Endglied kurz, konisch. Halsschild in der hinteren Hälfte glatt, mit einer verloschenen Grube vor dem Schildchen und zwei grösseren und tieferen Seitengruben an der Basis; die vordere Hälfte wird von den beiden annähernd halbkreisförmigen, kräftig punktirten Gruben der Kapuze eingenommen. Flügeldecken in regelmässigen Reihen nicht stark punktirt, ein Stück hinter der Basis quer eingedrückt, ausserdem noch mit einer anderen weiten Vertiefung in der Mitte zwischen der vierten und siebenten Punktreihe versehen, an deren Aussenrande die dritte secundäre Rippe auf eine kurze Strecke angedeutet wird. Die übrigen Zwischenstreifen sind eben und fast glatt.

Coelaenomenodera straminipennis sp. nov.

Elongata, straminea, nitidissima, antennis brunneo-rufis apice infuscatis, capite, prothorace laevi, postpectore utrinque tarsisque dilute brunnescentibus; cucullo rotundatim subquadrato, bifossulato, elytris striato-punctatis, tricarinatis, carina secunda medio interrupta, tertia antice deficiente.

Long., 6.5 mm.

Madagaskar, Tananarive, Mahatsinjo (*Donckier*).

In der Körperform mit *C. pallescens* übereinstimmend und auch in der Form der Halsschildkapuze ihr ähnlich, aber abweichend gefärbt, viel glänzender und durch die Skulptur der Oberseite völlig verschieden.

Strohgelb oder blass rötlich gelb, oberseits stark glänzend, Kopf und Thorax bräunlich gelb, eine verloschene Makel an den Seiten der Hinterbrust und die Tarsen hell rötlich braun, das zweite bis sechste Fühlerglied rotbraun, das siebente und achte angedunkelt, letzteres eine Spur dicker und um die Hälfte länger als das vorhergehende; die folgenden fehlen. Thorax länger wie breit, hinter der Mitte ziemlich parallel, die Kapuze davor etwas schmäler, von oben betrachtet an den Seiten ziemlich parallel, vorn über den Kopf vorgezogen und abgestutzt, mit breit abgerundeten Aussenecken und zwei sehr tiefen ovalen Gruben, welche durch eine mässig breite glatte Zwischenwand getrennt sind. Die Scheibe dahinter ist glatt und besitzt drei Eindrücke an der Basis und (wie bei den meisten anderen Arten) über dem Seitenrande zwei Längsvertiefungen, die von der Scheibe durch eine fast grade Leiste getrennt werden. Die Flügeldecken treten an der Basis schräg heraus und sind in den Schultern bedeutend breiter wie der Thorax, dahinter ziemlich parallel, jedoch hinter dem ersten Drittel durch den heraustretenden abgesetzten Seitenrand leicht erweitert, auf der Scheibe gereiht-punktirt, mit drei secundären Rippen. Diese haben ungefähr dieselbe Höhe, die erste ist im vorderen Drittel abgeflacht, die zweite kurz, in der Mitte unterbrochen, davor undeutlich, die dritte ist länger wie die zweite und erlischt allmählich vor der Mitte.

Von Mahatsinjo schickte Herr Donckier noch *C. chermesina*, *C. coccinea* und *C. ornata* ein.

Promecotheca straminipennis sp. nov.

Elongata, nigra, nitida, capite, thorace scutelloque sublaevibus, elytris, flavo-albidis vel stramineis creberrime striato-punctatis, parum nitidis, femoribus posterioribus dentatis.

Long., 11 mm.

Neu-Pommern (*Staudinger*).

Diese Art ist zwar ähnlich gefärbt wie *P. callosa*, aber viel schlanker gebaut und auf den Flügeldecken ganz abweichend punktirt. Sehr lang gestreckt, tief schwarz, glänzend, die Flügeldecken blass strohgelb, wenig glänzend. Kopf und Halsschild äusserst fein und schwer sichtbar gewirkt, letzteres mit einigen zarten Pünktchen jederseits in der vorderen Hälfte, hinten tief quer eingedrückt und eingeschnürt, davor an den Seiten keulenförmig erweitert und auf dem Rücken jederseits mit einer tiefen Grube versehen. Schildchen hinten breit gerundet-abgestutzt, deutlicher gewirkt wie der Thorax. Flügeldecken unbedeutend breiter wie der Vorderkörper, fast parallel, nur hinter der Schulter wenig ausgeschweift, hinten gerundet-verengt und in eine gemeinschaftliche kurze und stumpfe Spitze verlängert, oben wenig gewölbt, dicht gereiht-punktirt, die Punkte von mässiger Grösse. Es sind vorn zehn Punktreihen vorhanden, die in ein Drittel der Länge auf acht oder neun verringert, gleich darauf aber wieder auf zehn vermehrt sind. Die zwei ersten Reihen sind regelmässig, die beiden folgenden Reihen vermehren sich von etwa ein Viertel der Länge ab zunächst in drei, später in vier Reihen, während die sechste und siebente sich in ein Drittel der Länge mit der fünften verbinden und nun als eine Reihe bis vor die Spitze laufen. Eine ähnliche Streifung der Flügeldecken findet sich bei keiner anderen Art, denn die mit *P. cyanipes* verwandten Tiere haben vorn zehn, hinter der Mitte elf bis zwölf Reihen, da die dritte und vierte dort eine oder zwei Zwischenreihen erhalten.

Promecotheca antiqua Ws. ist in Neu-Pommern ein lästiges Tier geworden, da sie in den letzten Jahren mehrere Palmenpflanzungen vollständig verwüstet hat. Sie legt ihre Eier in den Vegetationskegel der jungen Pflanzen, den die zahlreichen Larven allmählich zerstören und so den Stamm zum absterben bringen. Kürzlich erhielt ich einiges Material durch meine

China, Tschonting (*Staudinger*).

Diese Art erinnert on *D. fulvipennis,* zeichnet sich aber durch den verhältnismässig breit abgesetzten und deutlich aufgebogenen Seitenrand des Halsschildes und die Punktirung der Flügeldecken aus, welche im grösseren Teile der vorderen Hälfte ziemlich erloschen ist.

Schwarz, wenig glänzend, die Flügeldecken dunkel bräunlich rot, glänzender. Kopf fast glatt, mit wenigen, nur bei starker Vergrösserung sichtbaren Pünktchen nahe den Augen. Halsschild etwas länger wie breit, nach hinten leicht verschmälert, sehr gering gewölbt, kaum bemerkbar gewirkt und weitläufig punktulirt, an den Seiten zu einer stärker punktirten, ziemlich breiten Rinne abfallend, welche den vorn verdickten Rand deutlich emporhebt. Auf den Flügeldecken sind die Punkte der beiden inneren Reihenpaare bis hinter die Mitte fast erloschen, die des dritten Paares fehlen auf der Schulter. Die erste Punktreihe steht der ganzen Länge nach in einer Rinne, von der sich in der Mitte die zweite abzweigt, die dritte und vierte Reihe nähern sich vor der Mitte und bilden dann bis zur Basis einen flachen Streifen; die fünfte und sechste Reihe trennen sich etwas vor der Mitte, und die beiden äusseren, deren Punkte von gleicher Stärke sind, bilden von ein Drittel der Länge bis wenig hinter die Mitte nur eine Reihe. Die erste Rippe bildet bis nahe an den Abfall zur Spitze, die zweite bis zur Mitte, und die dritte im ersten Viertel, eine ziemlich breite Fläche.

Downesia abdominalis sp. nov.

Elongata, nigra, nitida, abdomine rufo-flava, antennis sat longis, prothorace sublaevi lateribus subtiliter, marginato, elytris striato-punctatis, seriebus 7a et 8a ubique separatis.

Long., 6 mm.

Sikkim (*Staudinger*).

Aehnlich gefärbt wie *D. grandis,* sehr schlank, tief schwarz, glänzend, der Bauch rötlich gelb. Fühler länger wie in den meisten übrigen Arten, bis auf die Schulter reichend, Glied 2 etwas länger wie 1 oder 3. Halsschild wenig länger als breit, die Seiten hinter den Vorderecken schnell erweitert, sodann nach hinten allmählich unbedeutend verengt, äusserst fein gerandet, die Scheibe fast glatt, sparsam mit sehr feinen Pünktchen bedeckt. Flügeldecken in den Doppelreihen ziemlich fein punktirt, die beiden ersten vor der Mitte vereint, die erste Rippe bildet eine wenig deutliche schmale und niedrige Leiste, die beiden andern sind erloschen.

Downesia javana sp. nov.

Elongata, subdeplanata, rufa, nitida, antennis elytrisque (his basi excepta) nigris, tibiis tarsisque infuscatis; prothorace parce obsoleteque punctulato latitudine paullo longiore, lateribus evidenter marginato, elytris sat fortiter striato-punctatis, valde tricostatis.

Long., 3.5 ad 4 mm.

Java (*Drescher*).

Mit *D. sumatrana* nahe verwandt, aber nur halb so gross, dunkler gefärbt, die fünf letzten Fühlerglieder merklich dicker wie die vorhergehenden, die Punkte in den Reihen der Flügeldecken etwas feiner, dichter, die Rippen stärker.

Der Körper ist düster rot, glänzend, Fühler und Flügeldecken schwarz, letztere an der Basis unbestimmt rötlich, Schienen und Tarsen angedunkelt. Stirn glatt, mit wenigen Pünktchen zwischen den Augen. Thorax unbedeutend länger als breit, sparsam und sehr fein punktulirt, schwach gewölbt, die Seiten fast parallel, nach hinten wenig convergirend und vorn etwas gerundet verengt, über der feinen Kante des Seitenrandes mit einer vertieften Längslinie und vor dem Schildchen jederseits mit einer flachen Grube. Flügeldecken wenig breiter wie der Vorderkörper, parallel, die beiden ersten Rippen hoch und kräftig, nahe der Basis verbreitert, die dritte schwächer, die Intervalle tief, mässig stark in Doppelreihen punktirt, von denen die beiden ersten in den vorderen drei Viertel der Länge, die beiden letzten in der Mitte auf eine Reihe beschränkt sind.

Downesia sumatrana Gestro sammelte Herr Drescher im März, 1906, bei Samarang auf Java.

Die *Downesia*-Arten lassen sich in zwei Gruppen Teilen:

1. Die primären Rippen der Flügeldecken sind schmal und hoch, ihre Intervalle tief.
   - *a.* Halsschild längsrissig: *Downesia strigicollis, angustata.*
   - *b.* Halsschild fast glatt oder sparsam punktirt: *atrata, sulcata, basalis, picea, tarsata, insignis, sumatrana, javana.*
2. Die Rippen der Flügeldecken sind breit und flach oder kaum bemerkbar: *Downesia gestroi, fulvipennis, grandis, elegans, andrewesi, auberti, kanarensis, marginicollis, abdominalis.*

Agonia tristicula sp. nov.

Elongata, parallela, nigra, nitida, antennis articulis tribus ultimis flavo-albidis, basi femorum subtus macula rufa ornato, prothorace sat fortiter punctato margine antico linea media sat lata postice abbreviata costulaque angusta utrinque laevibus;

elytris coeruleo-nigris, fortiter striato-punctatis, tricostatis, costa tertia medio longe interrupta.

Long., 6.5 mm.

Borneo, Kuching (Sarawak Museum).

Aehnlich gefärbt wie *A. lucida,* an der Fühlerspitze ein Glied weniger weisslich und die Beine nicht einfarbig rotgelb.

Schlank, parallel, tief schwarz, glänzend, die Flügeldecken bläulich schwarz und mit Ausnahme der beiden ersten Rippen wenig glänzend, drei Endglieder der Fühler gelblich weiss und ein kleiner Fleck nahe der Basis auf der Unterseite der Schenkel rötlich gelb. Thorax so lang wie breit, vor der Mitte am breitesten und kaum schmaler wie die Flügeldecken, von hier nach vorn bis zu einem kleinen Ausschnitte hinter den Vorderecken unbedeutend, nach hinten allmählich etwas stärker, verengt, grob punktirt, ein Streifen am Vorderrande, in eine breite, hinten abgekürzte Mittellinie verlängert, sowie eine stumpfwinkelige Längsleiste jederseits über die punktirten Stellen erhöht und spiegelglatt. Flügeldecken stark in Doppelreihen punktirt, die durch drei Rippen getrennt werden. Die beiden inneren sind ganz, vorn mässig breit, nach hinten verengt, tief schwarz und spiegelglatt, die dritte ist schmal und nur nahe der Basis und vor der Spitze bemerkbar. Zwischen die dritte und vierte Punktreihe schiebt sich im ersten Drittel eine dritte Reihe ein.

Agonia luzonica sp. nov.

Elongata, subparallela, pallide rufo-flava, antennis, femorum apice, tibiis, tarsis, lateribus pectoris, abdominis et elytrorum (his in basi exceptis) nigris. Prothorace parce punctato, linea media subelevata carinulaque utrinque laevibus, elytris sat fortiter striato-punctatis, tricostatis.

Long., 5.5 mm.

Luzon (*Baker 2270*).

Var. *a.* Dimidio postico elytrorum ramulis tribus antrorsum emittente nigro.

Von den ähnlich gefärbten Arten durch die Rippen der Flügeldecken verschieden, von denen die dritte ganz und fast eben so stark ist wie die beiden inneren. *Gonophora chapuisi* Baly, die nach der Beschreibung ebenfalls zu *Agonia* gehört, weicht ausserdem noch durch rotgelbe Unterseite und Beine ab.

Gestreckt und ziemlich parallel, blass rötlich gelb, die Flügeldecken fast rein gelb, die Fühler, ziemlich die Spitzenhälfte der Schenkel, die Schienen und Tarsen, ein Streifen am Seitenrande der Hinterbrust und des Bauches, ein Spitzensaum der Flügeldecken, nach vorn auf der Naht bis zum ersten Viertel und am Seitenrande bis unter die Schulterbeule linienförmig verlängert, schwarz. In der var. *a* ist die hintere Hälfte der Flügeldecken schwarz und sendet einen gemeinschaftlichen, breiten, dreieckigen Zipfel auf der Naht bis zum ersten Viertel und einen schmalen Streifen am Seitenrande (innen von der dritten Rippe begrenzt) bis zur Schulterbeule. Fühler mässig lang, ihr drittes Glied um die Hälfte länger wie das zweite oder erste. Halsschild etwas breiter wie lang, an den Seiten hinten parallel, vor der Mitte schwach gerundet-verengt, auf der Scheibe ziemlich weitläufig, nach den Seiten zu dichter punktirt, eine wenig erhöhte und beiderseits abgekürzte Mittellinie nebst einer feinen, leicht gebogenen Längsleiste jederseits davon glatt. Diese Leiste begrenzt den vorderen Teil der normalen Seitengrube, die sich allmählich verschmälert bis zum Schildchen hinzieht. Auf den Flügeldecken sind die Punktreihen nicht besonders stark, aber dicht und regelmässig, nur zwischen die dritte und vierte Reihe ist vorn eine kurze Reihe eingeschoben.

Agonia chinensis sp. nov.

Elongata, postice leniter ampliata, lateritia, nitida, antennis nigricantibus basi ferrugineis, elytris nigris, nitidulis; prothorace parce punctato, antrorsum subangustato, elytris sat fortiter striato-punctatis, punctis antice seriebus septem, postice octo formantibus, costa tertia medio longe interrupta.

Long., 5 mm.

China, Kiautschau (*Staudinger*).

Durch Körperform, Farbe, und Skulptur der Oberseite ausgezeichnet. Gestreckt, nach hinten wenig erweitert, glänzend ziegelrot, Fühler schwärzlich oder pechbraun, die beiden ersten Glieder rötlich, Flügeldecken schwarz, mässig glänzend. Thorax hinten sehr sanft, nahe den Vorderecken stärker gerundet-verengt, oben gewölbt, sparsam kräftig punktirt, vor der Basis jederseits mit einem etwas dichter punktirten, schmalen, nach aussen verbreiterten Quereindrucke versehen. Flügeldecken in den Schultern wenig breiter wie das Halsschild und weniger eckig wie in den verwandten Arten, sondern mehr gerundetheraustretend, nach hinten schwach aber deutlich verbreitert, mässig stark gereiht-punktirt, dreirippig, die Rippen kräftig, die dritte jedoch nur dicht an der Schulter und vor dem Hinterrande vorhanden. Die inneren Rippen laufen parallel, deshalb sind die ersten vier Punktreihen ganz regelmässig und vorn, zwischen der ersten und zweiten Rippe, nicht um eine vermehrt wie in den meisten übrigen Arten; dagegen liegen auf der äusseren Hälfte nur im letzten Viertel vier, davor drei Reihen.

Agonia malangensis sp. nov.

Elongata, nigra, femoribus, tibiis, prosterno, capite (vertice excepto), prothorace (utrinque nigro-maculato) elytrorumque triente basali rufescentibus; capite laevi, prothorace parce punctato scutelloque nitidis, elytris minus nitidis, tricostatis, costa tertia medio interrupta.

Long., 3.5 mm.

Java, Malang (*Staudinger*).

Zu den kleinsten Arten gehörig, langgestreckt, fast parallel, der Vorderkörper und die Unterseite glänzend, die Flügeldecken fast matt. Unterseite schwarz, Schenkel, Schienen, und Prosternum gelblich rot, Seiten der Vorderbrust stark, die der Mittel und Hinterbrust feiner punktirt, letztere in der Mitte nebst den Bauchringen glatt, nur das Analsegment ziemlich dicht und fein punktirt. Fühler pechschwarz. Kopf gelblich rot, Stirn spiegelglatt, Scheitel schwarz. Halsschild wenig breiter wie lang, an den Seiten leicht gerundet und beiderseits schwach verengt, eine Querrinne, die den Vorderrand emporhebt und die Seiten (namentlich deren grosse Grube) ziemlich dicht punktirt, neben der etwas erhöhten Mittellinie jederseits nur wenige Punkte. Flügeldecken mit je vier regelmässigen Doppelreihen von starken Punkten und drei Rippen, von denen die beiden inneren gleichmässig kräftig sind, während die dritte nur nahe der Schulter und hinter der Mitte deutlich ist.

Agonia clavareaui Gestro.

Ein Exemplar des Sarawak Museums, Borneo; Quop, März, 1914, stimmt in allen Stücken mit der Beschreibung dieser Art überein, nur sind ausser den beiden Basalgliedern der Fühler noch die drei folgenden (wenn auch etwas dunkler) rötlich gefärbt.

Agonia (Distolaca) crassicornis Gestro.

Ist nach der Beschreibung unzweifelhaft eine *Javeta,* die ähnlich wie *gestroi* gefärbt, aber viel kleiner ist und ein kürzeres Halsschild hat. Ebenso könnte *pachycera* Gestro zu *Javeta* gehören, da der Raum von der Naht bis zur ersten Rippe mit drei Punktreihen besetzt sein soll.

Gonophora apicalis Baly.

Diese Art wurde nach einem einzelnen Stücke beschrieben; bei anderen Exemplaren von Luzon, Los Baños (*Baker*), sind die zwei ersten Fühlerglieder, die Basis des dritten, und die beiden Endglieder dunkel bräunlich rot. Die vier Vertiefungen des Thorax (eine kurze und schräge über den Vorderecken und eine längere und tiefere jederseits vor dem Hinterrande) sind mit je einer kräftigen Punktreihe besetzt. Viel stärker noch sind die Punkte in den Reihen der Flügeldecken, und deren schwarzer Spitzenfleck nimmt zuweilen etwas mehr als das letzte Drittel ein. Sein Vorderrand bildet zwischen den zweiten Rippen beider Decken eine grade Querlinie, nach aussen davon läuft er schräg nach hinten.

Anisodera nigricauda Motsch. gehört nicht zu *Micrispa*, wie ich[2] vermutete, sondern ist eine echte *Gonophora*, mit welcher *G. taprobanae* Gestro identisch ist. Das Exemplar meiner Sammlung stammt vom Originalfundorte Kandy.

Gonophora (Micrispa) javana sp. nov.

Ferruginea, subopaca, antennis medio flavis, lateribus postpectoris, ano, scutello, apice et macula laterali pone medium elytrorum nigris; elytris lateribus sinuatis, costa tertia pone medium interrupta.

Long., 3 mm.

Java, Noesa Kambangan, Januar 10, 1913 (*Drescher*).

In der Farbe und Zeichnung an *G. minuta*, in der Körperform mehr an *G. sinuata* erinnernd, kleiner als beide, und von ersterer schon durch die hell gefärbten Beine, von letzterer durch die wenig schwarz gezeichneten Flügeldecken leicht zu unterscheiden.

Gestreckt und schwach gewölbt, rostrot, die Ränder und die Erhöhungen des Halsschildes nebst den Flügeldecken noch heller und mehr gelblich, die Fühler blassgelb, das erste Glied und die drei Endglieder rostrot, Schildchen schwarz, die Seiten der Hinterbrust, das letzte Bauchsegment, die Spitze der Flügeldecken und eine Quermakel davor, vom Seitenrande bis zur zweiten Rippe ausgedehnt, schwärzlich. Stirn glatt, Halsschild annähernd herzförmig, vor der Mitte am breitesten, nach vorn wenig, nach hinten stärker, verengt, die Seiten stark gerundet, hinten leicht eingeschnürt; auf der Scheibe sind wie gewöhnlich zwei Querstreifen stärker vertieft, punktirt, die Mittellinie und ein Höckerchen jederseits davon erhöht und glatt. Schildchen hinten rechteckig, vorn erweitert. Flügeldecken hinter der Schulter deutlich ausgeschweift, hinten wenig verbreitert, die drei Längsrippen auf jeder kräftig, die dritte an der schwarzen Makel unterbrochen, die zweite bis zwei Drittel der Länge weiter von der ersten entfernt als dahinter und durch drei Punktreihen getrennt.

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[2] Deutsche ent. Zeitschr. (1904) 457.

Dactylispa spinosa Weber vergleicht Gestro[3] mit seiner *D. aspera* und rechnet sie zu den Arten mit vier Seitendornen des Halsschildes; sie besitzt jedoch nur drei (2, 1), denn Weber sagt: "Thorax spinis quatuor erectis, acutis, furcatis et duobus lateralibus minoribus simplicibus;" und Fabricius: "Spinis quatuor nigris, lateralibus trifidis, intermediis bifidis." Zur falschen Auffassung dieser kleinen, 4 Millimeter langen, rostroten, auf den Flügeldecken schwarzen Art von Sumatra ist Gestro durch den Vergleich eines Stückes aus dem Brüsseler Museum gekommen, welches von Chapuis ohne Grund für *D. spinosa* gehalten wurde.

Dactylispa flavolimbata, Sarawak, Serambu, Februar, 1913, und *D. malayana,* Sarawak, Banting, Mai 17, 1909 (auch von Herrn Drescher auf Java bei Noesa Kambangan im Juli, 1913 gefangen) sind nahe verwandt und bilden eine Gruppe die sich durch das Schildchen von den übrigen Verwandten absondert. Bei letzteren bildet dasselbe eine ebene, dicht und sehr zart gewirkte matte Fläche, während es in beiden oben genannten Arten zum grössten Teile von einer glatten ovalen Quergrube eingenommen wird, die vorn nur einen schmalen, jederseits verbreiterten, ebenen, und gewirkten Streifen frei lässt. Die drei Seitendornen des Thorax stehen auf einem gemeinsamen schlanken Stiele, die beiden ersten an der Spitze desselben, der dritte am Hinterrande wenig über der Basis. Der mittelste Dorn ist etwas länger wie die beiden anderen.

Dactylispa drescheri sp. nov.

Testaceo-flava, antennis piceis articulis 5 ultimis ferrugineis, elytris (limbo apicali excepto) nigris, sat nitidis, parce pilosis. Prothorace subopaco lateribus spinis tribus gracilibus, longis, proparte appendiculatis armato, elytris longe nigro-spinosis, spinis apicalibus brevioribus flavis.

Long., 4 mm.

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[3] Ann. Mus. Civ. Genova (1897) 86.

Java, Noesa Kambangan (*Drescher*).

In der Färbung an *D. weyersi*, *D. discoidalis* und *D. debilis* erinnernd; von ersterer durch die Farbe der Fühler und die zum Teil mit Anhängseln versehenen Thoraxdornen, von *D. discoidalis* durch die Thoraxscheibe, auf welcher der erhöhte glatte Querstreifen auf eine undeutliche, kleine, ovale Längserhebung in der Mitte beschränkt ist, und von *D. debilis* durch den nicht freien dritten Seitendorn des Halsschildes zu unterscheiden. Gelb, auf Brust, Bauch, und Thorax mit rötlich brauner Beimischung, die Flügeldecken schwarz, an der Spitze gelb gesäumt. Fühler schlank, die ersten sechs Glieder pechschwarz, die etwas verdickten fünf Endglieder dunkel rostrot; Glied 1 stark, 2 wenig schmaler, kurz, eiförmig, die folgenden vier dünn, 3 wenigstens so lang als 1, die drei folgenden kürzer. Die Dornen der Oberseite sind verhältnismässig lang, schlank. Der zweite Vorderranddorn des Thorax steht nicht ganz senkrecht, sondern ist schwach nach vorn geneigt und hat über der Mitte ein nach vorn gerichtetes Dörnchen. Von den drei Seitendornen ist der mittlere der längste, mit zwei Dörnchen versehen, und hat mit dem ersten einen gemeinschaftlichen Basalstiel, an dessen Basis auch der dritte entspringt. Dieser ist etwas kürzer als der zweite, aber etwas länger als der dritte Dorn; alle sind schwarz, an der äussersten Basis rötlich. Die Thoraxscheibe ist ziemlich matt, dicht verloschen und flach punktirt, mit zwei deutlichen Quer- und zwei unbestimmten Längseindrücken, durch die ein verloschener, kleiner, kaum punktirter Raum in der Mitte emporgehoben wird. Die Flügeldecken sind gereiht-punktirt (in jedem Punkte ein feines, aufgerichtetes greises Härchen) und haben ausser einigen kurzen Dornen nahe der Basis und dicht vor dem Hinterrande noch je ungefähr dreizehn lange Dornen, während der Seitenrand mit acht oder neun langen schwarzen Dornen besetzt ist. Am Hinterrande befinden sich je vier oder fünf kürzere rötlich-gelbe Dornen, von denen ein grösserer mit einem kleinen abwechselt.

Dactylispa secura sp. nov.

Nigra, elytris metallico-splendentibus, antennis longis, gracilibus, apice rufescentibus, prothorace creberrime punctato opaco, ante basin late transversim impresso, lateribus medio dilatato et bispinoso, elytris sat fortiter striato-punctatis, humeris bi-, dorso decem-lateribusque sex- vel septem-spinosis.

Long., 4 ad 5 mm.

Madagaskar, Mahatsinjo bei Tananarive (*Donckier*).

Von ähnlicher Gestalt als *D. dichroa*, aber kleiner und durch die nur zweidornigen Halsschildseiten ausgezeichnet. Schwarz; Stirn, Thorax, und Schildchen matt, die Flügeldecken glänzend, mit einem blassen Messingschimmer überzogen, die fünf letzten Fühlerglieder rotbraun. Stirn zum spiegelblanken Halse plötzlich abfallend. Fühler schlank, länger wie der halbe Körper; Glied 1 und 3 lang, 2 kurz, 4 und 5 etwas kürzer als 3, 6 und 7 jedes wenig kürzer als 4, das siebente nebst den folgenden Gliedern verdickt, 8 bis 10 kurz, jedes so lang als 2, das Endglied nur wenig länger. Thorax stark quer, die Seiten nach der Mitte hin winkelig erweitert; diese Erweiterung läuft in einen kurzen Stiel aus auf dem zwei mässig lange, wenig schräg, nach aussen gerichtete Dornen stehen. Unbedeutend länger ist der hintere, senkrechte Vorderranddorn, der vordere, der sich in sehr spitzem Winkel trennt, ist etwa halb so lang. Die Scheibe ist sehr dicht und etwas narbig punktirt und hat zwei Quervertiefungen, eine schwache und schmale hinter den Vorderranddornen und eine stärkere vor dem Hinterrande; zwischen beiden liegt ein undeutlicher Querwulst, nach innen zu einer glatten Mittellinie abfallend. Die Flügeldecken sind stark gereiht-punktirt, mit schlanken Dornen, von denen die mittleren viel länger als die an der Basis und Spitze stehenden sind. Ausser einigen Basaldörnchen befinden sich auf der Schulterbeule zwei Dornen, der erste kurz, der zweite lang; auf dem ersten primären Zwischenstreifen fünf (die drei mittleren lang), auf dem zweiten einer, hinter der Mitte, auf dem dritten vier Dornen, während die Seiten mit sechs oder sieben Dornen bewehrt sind. Von diesen sind der letzte oder die beiden letzten am Hinterrande sehr kurz.

Dactylispa aeneipennis Duviv.

Schwarz, Flügeldecken mit Bronceschimmer; ist dadurch ausgezeichnet dass die wenigen Dornen der Flügeldecken nur auf den äusseren zwei Drittel stehen, nämlich drei auf der Schulter (der erste kurz, der zweite mässig hoch, der dritte lang), und vier noch etwas längere (1, 1, 2) dahinter: der erste dicht hinter ein Viertel der Länge, der zweite dicht hinter der Mitte, beide zwischen der vierten und siebenten Punktreihe, die andern zwei vor der Spitze, einer an der hinteren Aussenecke, der andere zwischen der zweiten und vierten Punktreihe. Am Seitenrande befinden sich zwei lange Dornen, genau wie die beiden ersten Scheibendornen gestellt, am Hinterrande zwei Dörnchen.

Madagaskar, Mahatsinjo (*Donckier*).

Dactylispa excisa Kraatz var. repanda var. nov.

Von Kiautschau erhielt ich durch Staudinger eine *Dactylispa*, die eine Varietät von *D. excisa* bilden dürfte, auf welche ich durch den Namen *repanda* aufmerksam mache. Sie ist nur 4 Millimeter lang, schwarz, Fühler, Beine, und Bauch gelb, die Dornen des Halsschildes und drei Dornen im Ausschnitte der Flügeldecken etwas dunkler, rötlich gelb, die Scheibe der Flügeldecken mit Ausnahme der darauf stehenden Dornen glänzend rötlich pechbraun. Der vordere Dorn am Vorderrande des Thorax hat an der Basis ein dornförmiges Anhängsel, das kaum ein Drittel so lang ist wie der Dorn selbst, während der Seitenlappen nicht fünf, sondern nur vier Dornen trägt: drei längere, die auf einer gemeinsamen breiten Basis dicht hinter einander entspringen und einen weiter abgerückten, kürzeren dahinter.

Dactylispa adstricta sp. nov.

Piceo-nigra, opaca, antennis, pedibus ventreque rufo-flavis, prothorace creberrime subvarioloso-punctato et parce brevissimeque griseo-piloso, plagis tribus elevatis, glabris, alutaceis transversim positis, antice utrinque spinis duabus crassis verticalibus, longitudinaliter dispositis et basi alte connexis, lateribus spinis tribus rufo-flavis (1, 1, 1) armatis, elytris acute tuberculatis, crista humerali et lateribus (his paullo ante medium coarctatis) breviter spinulosis.

Long., 5 mm.

Japan, Harima (*Staudinger*).

Vor der Mitte stimmt diese Art im Körperbaue völlig mit der vorigen überein, hinter der Einschnürung aber erweitern sich die Flügeldecken nur ganz allmählich nach hinten; ausserdem sind die Fühler kürzer und dicker, und die ganze Oberseite ist matt pechschwarz, zart gewirkt oder gerunzelt, matt; Fühler, Beine, und Bauch lebhaft rötlich gelb, die mittleren Fühlerglieder 3 bis 6 mehr gelb, die drei Seitendornen des Halsschildes nebst dem langen und schmalen Lappen auf dem sie hinter einander stehen dunkler rötlich gelb. Fühler kurz, bis zur Schulter reichend; die fünf Endglieder bilden eine sehr schlanke Keule, an der die Glieder 8 bis 10 breiter wie lang sind. Stirn gerunzelt, ein vertiefter Streifen neben jedem Auge weisslich behaart. Halsschild um die Hälfte breiter als lang, dicht punktirt, in der Mitte mit einer Querreihe von drei gerundeten, erhöhten und nur zart gewirkten Flecken. Die beiden Dornen jederseits am Vorderrande sind schwarz, kurz, breit, senkrecht hinter einander auf einer hohen Längsleiste eingefügt, der erste hat in der Mitte des Vorderrandes eine kleine zahnförmige Erweiterung und ist etwas niedriger als der zweite; die drei Seitendornen sind etwas schlanker aber kaum länger, schräg nach aussen gerichtet, und stehen ebenfalls auf einer gemeinsamen Längsleiste. Die Flügeldecken treten an der Basis gradlinig heraus, sind in den Schultern bedeutend breiter wie der Thorax und erweitern sich dahinter bogenförmig in einen Lappen, der einem Kreissegmente ähnelt und kurz vor der Mitte endet, von hier aus erweitern sie sich allmählich nach hinten und sind am Ende breit und fast gemeinschaftlich abgerundet. Die Seiten sind kurz, vor der Mitte dicht, dahinter weitläufiger, und an der Spitze dicht und sehr kurz-gezähnt, die Schulter bildet eine Leiste, die mit fünf oder sechs Zähnchen bewehrt ist. Die Scheibe hat eine Anzahl kürzer und dicker zahnförmiger Erhebungen. Von diesen liegen vier auf der ersten, nur angedeuteten primären Rippe, nähmlich ein sehr kleiner Zahn nahe dem Schildchen, ein grosser vor und hinter der Mitte, und ein kleiner vor der Spitze. Die zweite Rippe hat zwei grössere Zähne, in und hinter der Mitte; neben dem letzteren steht ein ähnlicher Zahn auf der dritten Rippe, welche vorn noch einige unbedeutende Erhebungen hat.

Dactylispa aspera ab. matangensis ab. nov.

Der Thorax ist etwas stärker punktirt als bei der Stammform von Sumatra (die Punkte annähernd narbig, von einem erhöhten Rande umgeben) und die Flügeldecken sind einfarbig schwarz, vorn nicht rostrot. Ausser dem vorderen Dorne am Vorderrande des Halsschildes kann auch der hintere ein dornförmiges Anhängsel haben, oder beide sind einfach. Am Seitenrande stehen auf einem gemeinschaftlichen Stiele vier Dornen, die drei ersten unter sich gleich lang, der vierte viel kürzer und schräg nach hinten gerichtet.

Sarawak, Matang und Oya, August, 1910.

Von *Dactylispa longicuspis* Gestro befindet sich ein Stück im Sarawak Museum (Mount Poi, 3000 bis 3500 Fuss, April 17, 1913), mit einfarbig schwarzen Flügeldecken. Die Art ist durch die auffällig langen, mit variablen Anhängseln versehenen drei Thoraxdornen kenntlich, von denen die beiden ersten aus einem sehr langen gemeinsamen Stiele entspringen, an dessen Basis der kurze und einfache dritte Dorn befestigt ist.

Dactylispa fulvicornis sp. nov.

Fulva, elytris nigris, sat nitidis, antennis elongatis, articulo tertio longissimo, prothorace crebre punctato et breviter albopiloso, vitta media abbreviata sublaevi, lateribus bispinosis, spinis basi conjunctis, antica appendiculata, postica multo breviore, elytris spinis numerosis sat longis armatis.

Long., 5 mm.

Borneo, Sarawak, Lawas, August, 1909.

An der Bewehrung des Halsschildes kenntlich. Der hintere senkrechte Vorderranddorn ist doppelt so lang wie der vordere; an den Seiten stehen nur zwei Dornen: der erste ist fast eben so lang als der zweite Vorderranddorn, aber etwas stärker und mit mehreren Dörnchen besetzt, an seiner Basis entspringt der zweite, kurze, einfache, und schräg nach hinten gerichtete Dorn. Der Körper ist ziemlich gestreckt, rötlich gelb oder hell rostrot, die Flügeldecken schwarz, ihr abgesetzter Seitenrand an der Spitze etwas verbreitert, und nebst den dort befindlichen kurzen Dornen rötlich gefärbt. Fühler schlank, etwas länger wie der halbe Körper, ihr drittes Glied so lang wie die beiden ersten zusammen. Thorax dicht punktirt und zart weisslich behaart, matt, ein gewölbtes, beiderseits abgekürztes Querband in der Mitte fast glatt und glänzend. Flügeldecken mit zahlreichen schlanken Dornen besetzt, von denen der zweite in der ersten Reihe der längste ist, an den Seiten wechselt ein langer und ein kurzer Dorn ab, von zwei Drittel der Länge bis zur Nahtecke werden die Dornen allmählich kürzer.

Dactylispa rufiventris Kraatz.

Eine Reihe von Exemplaren vom Kamerunberge, Soppo, 730 m. (*v. Rothkirch* 1912) in den Vorräten Staudingers hat den Bauch einfarbig tief schwarz. Sonach trifft die Bemerkung von Kraatz,[4] "die Art ist an ihrer Grösse und dem roten Hinterleibe sehr leicht zu erkennen," nicht immer zu, und ich mache auf diese abweichende Form durch den Namen *D. nigriventris* aufmerksam. Die Art zeichnet sich durch das Halsschild aus. Die drei Seitendornen desselben, von denen der mittelste der längste, der dritte der kürzeste ist, sind von einander deutlich getrennt oder an der Basis nur genähert, und die glänzende Scheibe ist sparsam punktirt. Die Punkte sind gross und flach, narbig, stehen dichter in dem weiten, an den Seiten nach vorn gebogenen Quereindrucke vor der Basis, während sie in dem vorderen Quereindrucke eine oder zwei unregelmässige Längsreihen bilden. Die Länge der Art schwankt zwischen 5 und 7 Millimeter; Gyllenhal[5] hat sie, als var. β seiner *Hispa spinulosa* betrachtet.

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[4] Deutsche ent. Zeitschr. (1895) 197.

Hispa comata sp. nov.

Testacea, opaca, supra griseo-pubescens, prothorace ramulo elongato duodecim spinoso lateraliter armato, elytris striato-punctatis dense spinulatis, in disco spinulis, crassioribus subinfuscatis et gracilibus dilutioribus alternantibus.

Long., 3 mm.

Syria, Aleppo (*Staudinger*).

Einer kleinen *H. pavida* ähnlich. Rötlich gelbbraun, matt, auf dem Halsschilde sehr dicht, auf den Flügeldecken sparsamer weisslich behaart. Fühler ziemlich kurz, schwärzlich, Glied 2 kaum schwächer aber nur halb so lang as 1, 3 dünner und unbedeutend kürzer als 2, 4 und 5 kürzer als 3, 6 das kleinste, die folgenden Glieder verdickt, 7 so lang als 2, 8 bis 10 jedes kürzer. Der Thorax erweitert sich an den Seiten in einen langen und schmalen Lappen, welcher mit zwölf langen, feinen Dornen besetzt ist. Von diesen steht einer in der Mitte an der Basis und ist schräg nach vorn und innen gerichtet, die übrigen bekränzen die Seiten und liegen fast horizontal; die beiden letzten sind bedeutend kürzer wie die vorhergehenden. Wenn der letzte gespalten ist, was zuweilen und dann meist nur einseitig vorkommt, kann man dreizehn Dornen zählen. Die Punktirung des Halsschildes wird von der dichten Behaarung verdeckt. Die Flügeldecken sind gereiht-punktirt und ziemlich dicht bedornt. Die Dornen des Randes sind schlank, am Hinterrande verkürzt, die der Scheibe bestehen aus stärkeren, dunkler gefärbten, und etwas kürzeren, viel dünneren hellen Dornen.

Platypria moluccana sp. nov.

Ferrugineo-flava, elytris glabris, nitidulis, nigris (basi excepta), margine bilobatis, lobo antico sexspinoso, postico trispinoso.

Long., 5 mm.

Batchian, August, 1906 (*Koller*).

In der Körperform, Grösse, und Farbe am meisten mit *P. dimidiata* übereinstimmend, aber der Thoraxlappen bedeutend breiter, kürzer bedornt, und der vordere Seitenlappen der Flügeldecken mit sechs, der hintere mit drei Dornen besetzt. Durch diese Bewehrung tritt die Art näher an *P. echidna* und *P. squalida* heran, weicht jedoch von ersterer durch das einfarbige Halsschild und die dunkle Flügeldecken, von *P. squalida* durch unbehaarte und mässig glänzende Flügeldecken ab.

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[5] Schönh. Syn. Ins. App. (1817) 3.

Körper rötlich gelb, die Flügeldecken schwarz, eine Basalbinde der letzteren, ein feiner Saum zwischen den Seitenlappen und in der Spitze nebst dem matten, stellenweise dicht und sehr fein punktirten Halsschilde blass rostrot. Die Basalbinde reicht bis an die beiden ersten Scheibendornen und an den Anfang des Seitenlappens, von dem der erste Dorn und die innere sehr grosse Pore ebenfalls hell gefärbt ist, verlängert sich aber innen saumförmig auf der Naht bis an den zweiten Dorn der ersten primären Rippe. Die Fühler sind schlank, normal gebaut. Der Seitenlappen des Thorax ist halboval, schwach glänzend, mit fünf Dornen besetzt, von denen die ersten vier ziemlich lang sind, während der fünfte klein und kaum länger aber stärker als der vorn befestigte Borstenkegel ist. Die Flügeldecken besitzen am Basalrande zwei Dörnchen, auf der Schulter drei ziemlich kurze, auf der Scheibe sechs dicke und lange Dornen (2, 2, 1, 1), wovon die ersten beiden und der letzte Dorn (neben der hinteren Aussenecke) kürzer wie die übrigen sind.

MERRILLOSPHAERA, A NEW GENUS OF THE VOLVOCACEAE

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EIGHT PLATES AND ONE TEXT FIGURE

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INTRODUCTION

In 1859, Carter described what he supposed to be *Volvox globator* Ehrenberg, which he found in India, presumably in the neighborhood of Bombay. From Carter's description, Stein ('78, p. 134) recognized the plant as specifically distinct from all that had been described, and he named it *Volvox carteri*. Stein improperly regarded it as intermediate between the species *V. globator* and *V. aureus* of Ehrenberg, whereas in reality it is neither intermediate between those species nor even so closely related to either of them as they are to each other.

One of the several members of the subfamily Volvoceae which I have collected at Manila so nearly fits Carter's description that I shall treat it here as a mere variety. Yet this species differs so much from the earlier described species of *Volvox* that I shall assign it, with others, to a new genus. Carter noted the absence of protoplasmic connecting filaments between the somatic or vegetative protoplasts. There had long been in my mind a question as to the propriety of including in the genus

Volvox organisms so different from *V. globator* and *V. aureus* as to lack the intercellular protoplasmic connecting filaments. The question was answered for me by the early differentiation and large size of the asexual reproductive cells of this and of a related species. Carter described the asexual reproductive cells, the gonidia, as reaching a large size before undergoing segmentation. His figure of a gonidium ('59, pl. 1, fig. 4), which is reproduced on a larger scale in Plate 7, fig. 44, shows one that had reached a diameter of 85 μ. However, he did not appreciate the fact that such large gonidia, prominent in the daughter coenobia long before birth (as shown in his fig. 1, reproduced in Plate 7, fig. 42), are differentiated from the somatogenic cells (those which by division produce the somatic or vegetative cells) at a very early stage in the development of the embryo and remain large, while the somatogenic cells become smaller and smaller by the repeated divisions which produce the very numerous somatic cells.

Carter's account of the asexual reproduction seems to have been based on observations which failed to include the stages that commonly occur at night. Until I had made a few observations on living material through the hours of the night, my own work was in a fair way to muddle up in a description of one "species" forms that I now consider generically distinct. One of these forms I have already described under the name *Campbellosphaera obversa* (Shaw, '19). Its most distinctive character is a migration of the gonidia during the bowl stage of the embryo from the outside to the inside through the opening, or phialopore, just before the closure which converts the bowl-shaped embryo into a closed globular colony, or coenobium. The absence of such a migration is the important character that was revealed by the nocturnal study of the species which forms the subject of this paper.

Taking as a basis the characters found in the material in hand, I propose a new genus, **Merrillosphaera**, dedicated to Elmer Drew Merrill, the most indefatigable investigator of the flora of the Philippine Islands and the Indo-Malayan region. Believing this material cospecific with *Volvox carteri* Stein, I shall call it **Merrillosphaera carteri** (Stein) comb. nov. with the designation **manilana** for the form or variety first to be described in sufficiently full detail to furnish a basis for the recognition of the proper status of the genus. A very similar form was described by Powers ('08) under the name *Volvox weismannia.* It is both proper and convenient to reduce this to **Merrillosphaera carteri** *var.* **weis-**

mannia (Powers) comb. nov. Less fully described is a form collected and prepared by Migula, and called by Klein ('89B) *Volvox aureus*. This evidently is not the *Volvox aureus* Ehrenberg described by Klein ('89A and '90) but is a new species similar to *M. carteri* which I call **Merrillosphaera migulae** sp. nov.

Of another species of *Volvox*, one described by West ('10 and '18) under the name *V. africanus*, my Philippine material contains stages which fill out the life history and show its affinity with the species and varieties listed in the foregoing paragraph. It therefore becomes **Merrillosphaera africana** (West) comb. nov. (*Volvox africanus* West).

A third species of *Volvox*, described by Meyer ('96) under the name *V. tertius*, seems to fit into the new genus more readily than into any other, and this may be sufficient reason for classifying it tentatively as **Merrillosphaera tertia** (Meyer) comb. nov. (*Volvox tertius* Meyer). Of this species we have as yet only Meyer's description, which is in many respects very meager.

All of these species are characterized by having rounded somatic protoplasts without connecting filaments, and also by having gonidia which are differentiated at an early embryonic stage. To this extent they agree with *Campbellosphaera*, but they differ from the latter in lacking the migration of the gonidia through the phialopore into the coenobium. Two other species that lack interprotoplastic filaments develop their gonidia only after birth, and these I had previously assigned to two genera. Those with a reproductive area in which a small number of the cells develop into gonidia were put in the genus *Besseyosphaera* (Shaw, '16), while those with a reproductive area in which all of the cells develop into gonidia were put in the genus *Pleodorina* (Shaw, '94).

In presenting the descriptive details pertaining to the species and varieties of *Merrillosphaera* I shall begin with the descriptions of a series of specimens, selected primarily from those which have been photographed and that are supposed to represent the life history of *M. carteri* var. *manilana*, of which the first will constitute the type of the variety. Then the nearly related varieties of the literature will be taken up separately and described with the same terminology, for comparison with the variety in hand.

In another paper I purpose to extend our knowledge of *Merrillosphaera africana* (West) Shaw by means of descriptions of specimens in my collections.

Two species of *Volvox* proper that occur in my Philippine material more or less mixed with species of the related genera I have described in another paper (Shaw, '22) in which a special genus was made for the European species long known as *V. aureus* Ehrenberg.

MERRILLOSPHAERA CARTERI VAR. MANILANA VAR. NOV.

DESCRIPTION OF THE TYPE SPECIMEN

For the type of this variety, an asexual specimen (Plate 1, figs. 1 and 2) has been selected in order to exhibit a character which is essential to distinguish the genus from *Campbellosphaera.* This character appears in embryos that are in a stage which makes it fairly plain that the gonidia are differentiated early, but do not migrate.

The specimen (No. 1) is one of a batch collected from Pond C in Pasay, near the southern outskirts of Manila, September 20, 1914, and fixed at some time on the next day in picronigrosin. Material from this batch was mounted in glycerine on several slides and sealed with shellac. Slide 4 of this lot bears the specimen under a cover glass with glass rodlets measuring 309 to 354 μ, which were distributed for cover supports but are loose and now clustered at one side of the circle. The glycerine is strongly colored with picric acid. There is no record of the time when the mounts were made, but the photographs were taken June 13, 1916. So they were at the time of making measurements (July, 1919) more than three years old. The mount had then taken up no air bubble,[1] but the paper label of the slide showed glycerine on the edge nearest the cover, which raised a suspicion as to the security of the sealing. The slide bears a mixture of several species of Volvoceae. There are numerous hyphae extending into and through the glycerine; they appear to have developed in it.

The type specimen measures 545 by 590 μ. The upper and lower sides are seen with a difference of focal adjustment amounting to about 250 μ, which, with an allowance of 1.4 for the optical density of the glycerine, gives an estimated thickness for the specimen of about 350 μ. The area of the somatic surface that is flattened by the cover glass is about 350 by 400 μ in extent. Within this area the somatic protoplasts of the somatic wall are somewhat crowded and average about 9.5 μ between centers. Just outside of the flattened area the distance between cells is about 10 μ. This, with an approximate mean diameter taken as 560 μ, gives 11,400 as the number of cells. The protoplasts are somewhat farther apart in the anterior polar region.

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[1] The specimen has since been ruined, partly by escape of glycerine and formation of a large bubble, and partly by destructive movement of glass rodlets.

The somatic protoplasts are globose or oval, without connecting filaments. They are about 5.4 μ thick. Their distance from the outer membranous surface of the soma is about half a protoplastidar diameter or less. The outer surface appears quite even. The middle lamella between the protoplasts cannot be seen, nor is the inner limit of the cell membranes visible.

Eight embryos are contained in the coenobium,[2] occupying positions in the coenobial cavity near the coenobium wall, four just ahead of the equatorial plane and the four others alternating with them just back of that plane. The embryos are very darkly stained. They have developed into many-celled coenobia, in the walls of which gonidia may be seen embedded and protruding. Six of the embryos can be seen to contain small numbers of reproductive cells. Two of them are not so clear. The one which is shown in Plate 1, fig. 2, is about 90 μ in diameter; it has somatogenic cells of about 2.5 μ width, and contains four cells of about 8 μ diameter (which are not visible in the figure), grouped closely about what I take to be the site of the phialopore. It also contains eight cells about 17 μ in diameter, obviously gonidia, distributed in the coenobium wall—five near the median plane (two of which stand out clearly in the figure), one on the nearer side, and two on the farther side.

A well-marked feature of the embryos is that their gonidia are embedded in the layer of somatic cells where they are formed. Being more or less nearly isodiametric, and larger than the cells of the somatic layer, they protrude beyond the surface of the coenobium.

ASEXUAL COTYPE SPECIMENS

On the type slide are four other specimens of the same species, containing embryos in the same stage as those in the type specimen, or slightly younger. With them are twelve asexual coenobia with gonidia and two sexual coenobia with young oogonia. I will describe some of these specimens in order to bring out points that are not shown by the type specimen.

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[2] The use of the term "coenobium" for the bodies of these organisms is not consistent with my view that they are properly to be regarded as individuals rather than as colonies.

Specimen 2.—This coenobium contains eight embryos and presents an almost polar anterior view. Diameter, about 505 μ; thickness, about 365 μ; protoplasts, about 5 μ. Spacing of centers of cells: Anterior, about 20 μ; posterior, about 12 μ; and mean, about 15 μ. Estimate of somatic cells, 4,100. In the median focus there is seen a delicate line nearly parallel with the periphery of the optical section of the coenobium, forming an ellipse 280 by 300 μ in diameter, lying 110 to 120 μ within the outer membrane. The eight embryos lie in the zone between this line and the layer of somatic cells. These embryos are about 90 μ in diameter, and those that show clearly near the median level and above it have their phialopores directed outward. Around each embryo there are two distinct lines; these are the inner and outer limits of an embryo capsule which was formed by the wall of the gonidium from which the embryo developed. The embryo capsule touches the embryo on the side toward the center of the mother coenobium, is about 10 to 15 μ from the surface of the embryo around the equatorial plane of the embryo, and approaches without touching the embryo on the outer side. Around the equatorial region of each embryo its capsule is about 30 μ thick, while toward the poles it thins down until at the poles it becomes very thin, as if under radial pressure between a central coenobial core and the somatic layer of the mother coenobium. All the embryos show a few protruding gonidia, and these are most evident in the profile views of the embryos. The somatic cells are very much smaller than the gonidia. The embryonic phialopores are all more or less open and have the form of a four-pointed star. This is produced by the growth about the phialopores of four marginal lobes which for a time do not fit together, but which leave the star-shaped opening between them. The extent of the star is about one quarter of the circumference of the embryo. In some of the embryos the lobes are slightly raised and bent outward and bear on their tips one or more larger cells that are intermediate in size between the gonidia and the somatic cells. The embryos are so far apart that their capsules are not in contact with one another.

Specimen 3.—This coenobium contains eight embryos. It presents a side view, with the anterior pole a little lower than the posterior pole. Dimensions, 560 by 600 μ. Spacing of cells:

Anterior, 20 μ; equatorial, 13 μ; posterior, 15 μ; mean, about 15 μ. Estimated number of cells, 5,300. Somatic protoplasts, about 5 to 6 μ. A thick middle lamella of the somatic cells shows in a surface view, even under the low power. The embryos, about 90 μ, are closed or closing. The phialopores are directed outward, and a side view of one embryo shows the lobes around the stellate opening bent outward and tipped with large cells. The inner ellipsoidal membrane, or core boundary, of the coenobium is 330 by 358 μ, the zone between it and the outer limit of the coenobium being 115 μ in front and 130 μ behind. The inner lamella of the embryo capsule delimits the space about each embryo, but the outer lamella does not show.

Specimen 4.—An asexual coenobium with eight embryos, 565 by 593 μ. Spacing of cells: Anterior, 20 μ; equatorial, 15 μ; posterior, 13 μ; estimated mean, 15 μ. Number, 5,300. Embryos 85 to 95 μ, closing and closed, with gonidia protruding beyond the surface. Lobes about the phialopore bent outward in one embryo and bearing larger cells. Only the inner lamella of the embryo capsules is visible.

Specimen 5.—An asexual coenobium with six embryos and four gonidia. Oblique view. 562 by 590 μ. Spacing of cells, 10 to 13 (mean 11) μ. Number, 9,800. Embryos about 80 μ each, with protruding gonidia. Two of the gonidia of the parent, each about 64 μ in diameter, form a posterior pair; while the two others, with diameters of 68 and 70 μ, respectively, form a subposterior pair.

FEMALE COENOBIA

An asexual coenobium (specimen 6) with eight female daughters, which are distributed like the embryos in the type specimen, is shown in Plate 1, fig. 3. This specimen is of the same collection as the type specimen, but of a batch fixed one day later; that is, two days after collection. It is in a picro-nigrosin preparation mounted in glycerine; it was photographed in 1916, and was still in good condition in 1919. The coenobium measures 590 by 643 μ. The thickness of the specimen measured about 250 μ. Near by is a glass rodlet 265 μ thick, which was used to support the cover glass. The somatic protoplasts are about 5.3 to 5.9 μ wide. Their intercentral distances respectively are approximately these: Anterior, 21 μ; equatorial, 14 μ; posterior, 17 μ; and mean, considering the relative extent of the different areas, 16 μ. This gives the estimate of the number of cells, 5,250. The daughters all contain reproductive cells, which are more numerous and smaller than gonidia would be at the same stage. They are the female reproductive cells. One daughter, the second from the left in the upper row, measures 178 by 180 μ. The somatic protoplast diameters are about 3.6 μ; the intercentral distances, about 4.9 μ; and the estimated number of cells, 4,850. The oogonia are about 15 μ in diameter, number about 24, and are distributed just under the somatic layer in all except the anterior quarter of the daughter, this quarter being at a higher level than the picture plane. Over each oogonium there is a vacancy in the layer of somatic cells, this space being surrounded by seven or eight somatic cells. Each of the other daughters shows an area lacking reproductive cells, and all the daughters have nearly the same dimensions and about the same number of somatic cells and reproductive cells. The smallest is 145 by 150 μ, the largest 175 by 190 μ. The oogonia were counted and measured in three other daughters which are above the median plane. The counts are 27, 37, and 31, and the measurements 13, 15 (exceptionally 11 and 16), and 14 μ, respectively. The smallest oogonia are a few of those in the coenobium that contains the largest number. The oogonia are vacuolate protoplasts, each with a central nucleus and with parietal chromatophores. No membranes can be seen except the outer limiting membranes of the mother and of the daughters. The position of the inner lamella of the embryo capsules seems to be marked by confinement of the cilia of the daughters to a space having a width that is much less than the length of the cilia.

A nearly mature female coenobium (specimen 7) from slide 1 of the type lot is shown in Plate 1, fig. 4. This specimen measures 264 by 380 μ, and has a thickness, in its compressed condition under the cover glass, of about 186 μ. The somatic protoplasts are 4.4 to 5.3 μ wide, and the distances between their centers are, approximately: Anterior, 12.5 μ; equatorial, 10 μ; posterior, 9 μ; and mean, about 10.2 μ. The estimated number of somatic cells is 4,850. Distributed in about three quarters of the coenobium, and located about 25 μ below the outer surface, there are twenty-nine reproductive cells, of which five have thickened walls which mark them as oospores. These oogonia are mostly about 27 μ in diameter, two exceptional ones near the posterior pole measuring 22 and 25 μ, respectively. Over each reproductive cell there is a vacancy in the layer of somatic cells, each such space being surrounded by about six somatic cells. In the reproductive region, and anterior to the equator, there are discernible five vacancies in the somatic layer without corresponding reproductive cells. These may be the sites of antheridia, but I do not think it likely. The oospore walls are not very strongly developed. They measure about 32 μ across, except one containing a protoplast which appears to be pathologically plasmolized into a bowl shape, and this wall measures 35.6 μ. These walls are smooth, and concentric with the protoplast, except one which is eccentric.

A more-mature female coenobium, one containing nearly ripe oospores, is shown in Plate 4, fig. 24. This specimen (No. 8) is in a collection taken from Pond I, less than a hundred yards from Pond C, in Pasay, October 5, 1914. It is on slide 1 of a lot of picro-nigrosin glycerine preparations made from the same collection. The cover glass is supported only by a shellac ring and has flattened the large coenobia, reducing their thickness to about 112 μ. The cleft in the forward pole is a result of the cover-glass pressure. Measurements of coenobia in such a flattened condition are not very satisfactory, and those made of this one in 1921 do not accord with the dimensions of the photograph. The specimen now measures about 693 μ wide and 737 μ long. The average spacing of the protoplasts is about 13.3 μ, and the number of cells is estimated to be between 6,000 and 8,000. The protoplasts are about 6 by 7 μ in diameter. There are thirty-six mature oospores, and there are two unmatured reproductive cells with them. The two dark bodies in the anterior circumpolar region are a green endophyte like a *Chlorosphaera.* The oospore walls shown in Plate 4, fig. 29, have a very slightly wavy appearance that is more pronounced in direct view of some spores. They measure in outside diameter about 50 μ, appear to be about 2.5 to 3 μ thick, and contain protoplasts that are mostly about 39 μ thick and in contact with the wall at one side and therefore eccentric.

MALE COENOBIA

A mature asexual coenobium containing male and asexual progeny is shown in Plate 1, fig. 5. This specimen (No. 9) is on the same slide as the female coenobium described in the preceding paragraph. This mother coenobium is turned away from the observer approximately 22°. On the farther side of the coenobium there is in the somatic layer a cleft about large enough for the birth of an offspring. If one of the progeny passed through that cleft it was the member of the anterior quartet located on the farther side. There remain in the anterior quartet an asexual and two male coenobia, and the posterior quartet consists of three asexual and one male coenobia. Within the mother coenobium, near the cleft, there is an anomalous object consisting of an irregularly shaped and bent sheet of hundreds of small cells. It is like a piece torn out of the somatic layer of one of the asexual offspring, but the cells are much smaller. The mother coenobium in its flattened condition measured, in 1919, about 678 by 685 μ. The corresponding dimensions of the photomicrograph are 650 and 660 μ, which indicates that three years of drying have brought the cover glass closer to the slide and squeezed the large specimens flatter, thus making them wider. The specimen measured about 112 μ in thickness. The somatic protoplasts are about 6 to 7.1 μ thick. The outer walls of the somatic cells are slightly convex, especially around the anterior pole, giving the surface of the coenobium a wavy appearance in optical section. The spacing of the somatic cells is about as follows: Forward, 22 μ; in the middle, 17 μ; at the back, 18 μ; average, about 17.5 μ. The consequent estimate of somatic cells is 5,480.[3] Each asexual daughter contains eight gonidia, and over each gonidium there is a vacant place in the layer of somatic cells. The daughter nearest the middle of the picture is 210 μ wide and 230 μ long. Its somatic protoplasts are about 3.6 μ wide, and their centers are about 4.1 μ apart. The number of cells indicated by these figures is 10,100.[3] The gonidia are about 30 μ in diameter. There are pressure creases in the coenobium walls of two of the daughters. Of the male offspring, the lower is 240 by 280 μ, the right one 240 by 290 μ, and the upper one 260 by 270 μ. The last of these has somatic protoplasts about 5.3 to 5.4 μ thick and spaced 10 μ between centers. The estimate of somatic cells is 2,500.[3] Scattered throughout the periphery of the coenobial cavity are 112 or more androgonidia, the cells which produce, by dividing, the bundles or platelets of sperms, mostly with one or two of the segmentation divisions accomplished. A few undivided ones are 10, 14, and 16 μ wide. Those in the 2-celled stage are mostly about 17 by 19 μ, and those in the 4-celled stage about 19 μ each way. The counting of the androgonidia was done by making a camera lucida sketch, in which difficulty was experienced due to overlapping of the progeny in their flattened condition. The number is evidently about the same in all, and is in the neighborhood of 120.

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[3] The estimate is probably much too high on account of the flattening of the coenobium.

A free male coenobium (specimen 10) in the same collection as the type specimen is shown in Plate 1, fig. 7. After it was photographed the specimen became crushed between two glass rodlets so that the antheridia cannot be counted. The somatic protoplasts are about 4.5 to 5 μ wide and spaced about 12 μ. The diameter of the coenobium being about 253 μ, the number of the somatic cells is about 1,600. The reproductive bodies are all sperm platelets that are more or less cupped and measure 14 to 19 μ in diameter. They are too darkly stained to admit of counting the sperms. The specimen shows plainly the cilia of the somatic cells and of the sperms. Each sperm platelet is contained in a cavity about 46 μ in diameter.

Two free male coenobia that appear to belong to the same species are in company with the specimen shown in Plate 1, fig. 5. They are very similar to the males within this mother. These two specimens (Nos. 11 and 12) are 295 by 316 μ and 316 by 324 μ in diameter and have about 1,700 and 1,800 cells. The somatic protoplasts are about 7 μ in diameter and measure about 23 μ wide. The antheridia number about 200 in each coenobium and are distributed without leaving a well-marked vegetative pole. They are mostly in the 16-celled stage of division, though some have divided only once or twice. On the same slide with them there is a larger male coenobium that I take to be of another species. It is larger, 390 by 413 μ, and has smaller cells, 6 μ, that are more numerous, about 2,900. The antheridia also are smaller, 18 μ, and more numerous, about 640. This coenobium has no vegetative pole marked by absence of reproductive cells, but the posterior half is narrowed slightly as is commonly the case in *Merrillosphaera africana.*

FORMS OF ASEXUAL COENOBIA

The photomicrographs used for illustrating this paper have been selected from about one hundred fifty that were made to serve as an aid in the task of separating the five or six species of larger Volvocaceae that occurred in various mixtures in the collections made in the neighborhood of Manila. This was done at a time when the number of species and genera was not known. The selection of material was based largely on suitability of the specimens for photography. A result of thus working simultaneously with a number of species is that no one species was followed as far through its range of variation as might have been done had it been studied alone. Since the photographed preparations were made, large quantities of material have been collected in different years.

The form selected to serve as the type of *Merrillosphaera carteri* var. *manilana* has most commonly eight gonidia, of which four form a quartet of equidistant gonidia lying in a transverse plane a little in advance of the equatorial plane and the other four form a similar quartet just back of the equatorial plane, the members of the two quartets being located on alternating longitudinal radial planes. In such cases the reproductive bodies occupy a middle zone of the coenobium and leave two polar zones without reproductive bodies. In other cases there is no empty space back of the hinder quartet. A third quartet of gonidia may be present in the hinder part of the coenobium or may be represented by fewer than all of its members. When two of these members are present they are usually on opposite sides of the polar axis. The members of the third quartet are smaller than the others, whether gonidia or daughters, and their segmentation is commonly delayed with respect to that of the others. Occasionally members of the second quartet are lacking. Some examples of the numbers and arrangements of the asexual reproductive bodies are given in the following descriptions of coenobia that have been photographed.

A mature asexual coenobium containing only asexual daughters is shown in Plate 2, fig. 8. This specimen (No. 13) is one of a collection taken from Pond C on the day after the type material was collected, and fixed on the same day. When photographed in 1916 the preparation in which it was included seemed in fairly good condition, but by 1919 most of the specimens on the slide had become disorganized. The micrograph shows a coenobium about 620 by 700 μ and an average spacing of the somatic cells of about 17 μ. These figures correspond with a cell number of about 5,200. Camera lucida sketches of six of the eight daughters gave eight gonidia in each. The other daughters were too obscure for sketching. The gonidia were about 20 to 24 μ in diameter.

A mature asexual coenobium with nine daughters is shown in Plate 6, fig. 39. This specimen (No. 14) is from the same preparation as the preceding one. From the photograph the number of somatic cells appears to be about 8,600.

A mature asexual coenobium with ten daughters is shown in Plate 5, fig. 34. This specimen (No. 15) is also from the same collection as the preceding one. It is very much flattened by the cover glass, and the anterior pole is turned away from the observer approximately 24°. The members of the two quartets are symmetrically arranged, and the posterior pair of smaller daughters lies almost in the middle of the picture. The total number of gonidia in the ten daughters is about seventy-seven.

A mature asexual coenobium with only seven daughters is shown in Plate 6, fig. 41. This specimen (No. 16) is from the same lot as the preceding. A member of the posterior quartet is missing. A half-grown coenobium with only six gonidia is shown in Plate 2, fig. 11. This specimen (No. 17) is from the same source as the preceding. The six gonidia are about 50 to 53 μ in diameter and are very symmetrically arranged in an anterior quartet and a posterior pair.

An asexual coenobium with eleven daughters, all asexual, is shown in Plate 2, fig. 12. This specimen (No. 18) was taken on October 2 and fixed on the following day. The daughters are arranged symmetrically, eight larger ones being distributed in two quartets in the equatorial zone and the three remaining ones, which are smaller, as if in a quartet with a missing member, between the equator and the posterior polar region. In seven of the daughters it was possible to count eight gonidia. In the others not more than seven could be seen with certainty.

An asexual coenobium with eight female daughters is shown in Plate 3, fig. 18. This specimen (No. 19) is from the same collection as the one shown in Plate 1, fig. 3, but fixed a day earlier. It differs from that one mainly by having the second quartet of daughters not so far from the posterior pole of the coenobium. The oogonia in the nearest daughter numbered twenty-one and measured about 15 μ in diameter. The positions of the daughters are unfavorable for showing the part of each around the anterior pole that lacks oogonia.

The following specimens are from the same collection as the type specimen:

Specimen 20.—Plate 6, fig. 37, shows a side view of a coenobium with eight gonidia somewhat out of the typical positions. The gonidia are about 60 μ in diameter.

Specimen 21.—Plate 6, fig. 38, gives a view of a similar coenobium that is tilted about 45° away from the observer. The gonidia are 53 to 60 μ in diameter.

Specimen 22.—Plate 5, fig. 32, gives a posterior polar view of a coenobium with ten gonidia, of which the members of the hinder pair are about 53 μ and the others about 64 μ in diameter.

Specimen 23.—Plate 1, fig. 6, shows a young coenobium with eight gonidia that are mostly about 27 μ, one being about 25 μ in diameter.

Specimen 24.—Plate 3, fig. 19, shows another young coenobium with seven gonidia, of which six are about 28 μ and one about 24 μ in diameter.

From the same pond that yielded specimens 8 and 9 (Plate 4, fig. 24, and Plate 1, fig. 5) the following specimens were obtained:

Specimen 25.—Plate 2, fig. 13, shows an asexual coenobium with eight gonidia in process of division. The specimen is very much flattened by the cover glass. The reproductive body at the right in the upper row and the first and third ones in the lower row are in the 4-celled stage. The others are 2-celled. They measure about 90 μ wide.

Specimen *26*—Plate 5, fig. 33, shows an anomalous case in which one of the eight reproductive bodies is smaller than the others. It measures 28 μ wide, the others being 46 to 50 μ.

From another pond, J, on October 13, a collection was made from which the following specimens were selected:

Specimen 27.—Plate 3, fig. 17, gives a side view of a typical coenobium with nine gonidia of which the larger ones, about 46 μ wide, form two characteristic quartets and a smaller one, 35 μ wide, occupies one of the places of a third quartet.

Specimen 28.—Plate 3, fig. 15, shows an asexual coenobium with five asexual daughters and three gonidia. It is tilted approximately 12° away from the observer. The daughters are the anterior quartet and the left, distant (out of focus) member of the posterior quartet. The mother coenobium is only very slightly compressed by the cover glass, but the daughters are flattened parallel with the coenobium wall. Each of the daughters contains eight gonidia, which are about 12 μ in diameter. The gonidia of the mother are about 85 μ in diameter.

SMALLER FORM OF THE SPECIES

From a small pool, B, in Pasay, about a quarter mile from the ponds, there was taken, in company with a species of *Volvox*, what appears to be a small form of *Merrillosphaera carteri* with smaller gonidia. I shall assume that it is such and describe the specimens that are figured.

Specimen 29.—A mature asexual coenobium with eight asexual daughters is shown considerably flattened in Plate 3, fig. 20. It presents a posterior view, and near the posterior pole there is a contracted opening through which a daughter may have been born. Each of the daughters contains eight gonidia except the upper one, which has nine. The diameter of the mother is about 570 μ (compressed to about 112 μ thick), of the uppermost daughter about 175 by 190 μ, and of the smallest about 130 by 135 μ. The number of cells in the mother was estimated to be 3,300 (probably less), in the uppermost daughter 1,700, and in the smallest daughter 1,500. The gonidia of the uppermost daughter measure 18 to 25 μ, and of the smallest 18 to 19 μ.

Specimen 30.—An asexual coenobium, Plate 5, fig. 36, with twelve reproductive bodies, ten of them segmented and two unsegmented gonidia. The two gonidia are in the hinder part of the coenobium and measure 54 and 54 by 57 μ. The others have divided into 2, 4, or 8 cells, and are in process of dividing again. The number of cells in the coenobium was estimated at 5,000, though it is probably considerably less.

Specimen 31.—An asexual coenobium with eight gonidia very symmetrically arranged is shown in Plate 2, fig. 14. It measures about 350 by 380 μ and has about 2,800 somatic cells. The gonidia measure about 50 to 55 μ.

Specimen 32.—A slightly younger asexual coenobium shown in Plate 2, fig. 9, has nine gonidia that measure about 53 μ, 55 μ, and 46 μ. The number of somatic cells was estimated to be 2,750.

Specimen 33.—A still younger coenobium with ten gonidia that do not conform to the typical arrangement is shown in Plate 3, fig. 16. In this the smaller gonidia are two, nearest the forward pole, that measure 37 and 39 μ, the others measuring 43 and 43 to 46 μ. The number of cells in the coenobium was estimated to be 1,800.

Specimen 34.—The youngest free coenobium shown of this lot is the one given in Plate 2, fig. 10. It contains twelve gonidia symmetrically arranged but with the middle quartet rather forward and separated from the hinder quartet. The number of somatic cells was estimated to be about 2,800. The gonidia measured 32 μ in the first and second groups and 28 μ in the third group.

On the same slide with the specimens numbered from 29 to 34 are twenty-two others of the same form. Some of these, like specimen 30, have the gonidia segmented. Two of these are noteworthy. They are:

Specimen 35.—This is an asexual coenobium similar to specimen 31. It has eight reproductive bodies very symmetrically arranged. One of the hindmost four is a gonidium of about 49 μ diameter. The others have segmented into four and eight cells. This points to the undivided gonidium being probably full-grown. The number of somatic cells was estimated to be about 1,000.

Specimen 36.—The smallest coenobium with large gonidia is one measuring 213 by 220 μ and presenting an anterior view. Its somatic cells were estimated to be 730. It contains eight gonidia that are about 42 μ in diameter.

An undated slide of material from near the same source as the preceding small form bears three that are figured herewith. They are:

Specimen 37.—An asexual coenobium with eight gonidia that are all divided, two into 2 cells and the others into 8, 16, or 32 cells, is shown in Plate 5, fig. 35. In the picture the coenobium measures 400 by 425 μ. On the slide it measures only 328 by 340 μ. I would think the magnification to be wrongly stated but for the fact that the reproductive bodies are about the same size as shown in the picture.

Specimen 38.—An asexual coenobium with eight gonidia, shown in Plate 3, fig. 21, has about 1,600 somatic cells.

Specimen 39.—The smallest specimen shown is the one shown in Plate 3, fig. 22. It measured 138 by 144 μ, and was estimated to have about 500 somatic cells. It has seven gonidia of about 19 to 22 μ. The apparent angularity of the cells in the photograph is an optical effect that is more marked on those that are out of focus, and probably due in part to the shadows of the cells of the farther side of the coenobium.

A similar small form of the species was present in Pond Q in 1915. Some material taken from there on October 2 was stained with Bismarck brown, mounted in Venetian turpentine, and photographed. They all show considerable shrinkage and have shrunken further since the photographs were made.

Specimen 40.—An asexual coenobium with eight gonidia of about 35 to 40 μ diameter is shown in Plate 4, fig. 28.

Specimen 41.—An asexual coenobium with eight symmetrically arranged gonidia of about 57 μ diameter is shown in Plate 4, fig. 27. In the photograph the coenobium measures 230 μ wide and 220 μ long. In 1921 the specimen had shrunken further to 206 μ wide and 191 μ long. Most of the shrinkage occurs in the membranes. Each gonidium is contained in the outer side of a gelatinous capsule that is very thin on the outer side and so thick in other directions as to crowd the neighbor capsules so that all form flattened surfaces of contact. There is little if any trace of a central core of the anterior part of the coenobium. If present, it is reduced to a bit about 15 μ thick and 50 μ wide. The somatic layer of cells has membranes so proportioned as to form a thin layer over each gonidium and a thick layer in other parts of the coenobium wall.

Specimen 42.—An asexual coenobium with ten daughters, shown in Plate 4, fig. 26, presents a side view with the characteristic arrangement of two groups of four and a hinder pair of smaller daughters. The central core of the anterior part of the coenobium seems to be present.

Specimen 43.—An asexual coenobium with twelve daughters is shown in Plate 4, fig. 25. In this the four hindmost daughters are smaller than the others.

CELL MEMBRANES

In some Venetian turpentine preparations of material stained with Bismarck brown the cell membranes are rendered visible, partly by the stain and sometimes, apparently, partly by the absorption of water by the membranes. One specimen from Pond E, November 1, 1914, was selected to illustrate the cell membranes. Particulars in regard to this specimen follow.

Specimen 44.—An asexual coenobium with eight daughters was photographed as shown in Plate 4, fig. 31, on May 15, 1916. On the following day it presented a different appearance and was again photographed as shown in Plate 4, fig. 30, and Plate 6, fig. 40. It was believed to have rotated with a slipping movement of the cover as a result of the slide having been left in a vertical position. The first picture seems to be a side view of a coenobium that has had the poles flattened by pressure,[4] and the others appear to be anterior polar views in which the flattened condition of the poles does not show. It is evident from all of these figures that the somatic cells form a layer, which is thin over the daughters and thick between them and over the poles. The membranes of the somatic cells form prisms with the protoplast in the outer end of each. In the thicker parts of the coenobium wall these prisms are about 18 μ high; over the daughters they grade down to only a small fraction of that height. The outer ends of the prisms are slightly convex in the photographs. By further shrinkage they have become, in 1921, very convex. So it appears that the convexity shown in the figures is probably largely a result of shrinkage. Plate 4, fig. 31, shows something of the thick capsular membranes around the daughters.

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[4] This flattening of the poles may have been due to great shrinkage of the parts of the coenobial core that filled the front and back of the coenobial cavity.

MIXED REPRODUCTIVE BODIES

Rarely (twice) coenobia were found that contained an anomalous mixture of reproductive bodies. One such from Pond F was found associated with a nearly typical form of this species. It will be described next.

Specimen 45.—Plate 3, fig. 23, shows a coenobium containing thirty-five reproductive bodies of three kinds. It measured in 1916, 435 by 440 μ with a thickness of about 300 μ. Now, in 1921, its thickness is less and its dimensions are greater. The number of somatic cells was estimated to be about 4,360. Four of the reproductive bodies are asexual daughters. In one of these eight gonidia can be counted. In the others only six or seven can be seen, though there is some obscurity. Fourteen of the reproductive bodies are cells about 42 μ wide, and seventeen are smaller cells about 26 to 32 μ wide. The former are vacuolate cells that I have supposed to be gonidia, and the latter are set down in my notes as oogonia. This assumption may be wrong. As before stated, this specimen is to be regarded as an anomaly.

MERRILLOSPHAERA CARTERI VAR. TYPICA VAR. NOV.

Carter's description ('59, pp. 2 to 5 and 18 to 19, pl. 1, figs. 1, 3, 4, 7, 8, and 10), given under the name of *Volvox globator*, will now be recast in the terminology used in the present paper. His figures of this species are reproduced herewith in Plates 7 and 8 on larger scales to make their dimensions directly comparable with the micrographs of the Philippine material. His measurements were given in fractions of an inch.

The form of the adult coenobium was described by Carter as spherical, or nearly so. The size, he stated, equals 770 μ. A nearly mature asexual coenobium which he figured (Plate 7, fig. 42) measured, according to the scale given, about 744 μ broad by 765 μ long. An oosporic coenobium which he figured (Plate 8, fig. 46) and stated to be the largest he had seen and about 608 μ in diameter, measures 606 by 616 μ. An antheridial coenobium shown in his fig. 8 (Plate 8, fig. 48) was stated to be about 270 μ and the figure measures about 283 by 287 μ. The diameter of the daughters before birth is shown to be at least as much as 192 μ, at which time the gonidia of the daughters are about 32 to 42 μ in diameter; and, according to the figure, while the gonidia in different daughters of the same parent vary, all the gonidia in any one daughter are about equal in size. An asexual coenobium in which the gonidia had not yet segmented, as indicated by the statement that the coenobium contained only one generation, shown in his fig. 3 (Plate 7, fig. 45), measures by the figure 637 by 643 μ.

The number and size of the somatic cells were not given. These cells were described as globular and biciliated. Carter's fig. 1 *a* (Plate 7, fig. 43) of such a cell shows no intercellular protoplasmic filaments, though this point loses significance when we note that his figure of a somatic cell of a true *Volvox* on the same plate (fig. 2 *a* of his plate) shows a stellate protoplast without depicting the intercellular filaments which are characteristic of that genus.

The number of the gonidia was given as generally eight, and emphasis was laid on the statement that they are distinctly visible in the daughters before birth. The distribution of these gonidia in the coenobia was not indicated more particularly than by the specification: "Daughters confined to the posterior three fourths of the sphere, the anterior fourth being empty." The "almost mathematically regular arrangement" of the gonidia, which was emphasized by Powers ('08, p. 153) in his description of the American variety, is masked in Carter's figures by a degree of artificiality. This artificiality of the figures is evident from the fact that, of the sixty-four gonidia in his fig. 1 and the eight gonidia in his fig. 3, no two overlap. Even the overlapping of the daughters in his fig. 1 was kept down as much as possible. With this in mind, we can appreciate the probability that the arrangement of the gonidia in Carter's material was as regular as has been found in any variety of this species.

Carter's statement that each "daughter" (that is, gonidium) consists of an enlargement of a peripheral (somatic) cell referred, for illustration, to his fig. 11, which he listed as representing another species, described in the same paper, and that happens to be a true *Volvox*, wherefore we may discount its strict applicability to the species under consideration. Acording to his account (Carter '59, p. 3), as the gonidium—

> enlarges, the chlorophyll and protoplasm together are seen to form an areolar structure around the internal periphery of the cells (fig. 4), which

goes on increasing in size, and the starch-cells and chlorophyll increasing in number and quantity respectively, until a sudden re-arrangement of the gonimic contents takes place, and the whole is transformed into a globe of peripheral cells.

The figure (Plate 7, fig. 44) shows a gonidium about 85 μ in diameter. It represents the chloroplasts as forming a peripheral network with expanded nodes containing pyrenoids. The resemblance of the nodes of the chloroplast network in this figure to the somatic protoplasts of *Volvox globator* (compare Overton, '89, pl. 1, fig. 4) is so great that Klein ('89A, p. 196) was led to interpret the figure as representing a small coenobium of that species. The vacuolate protoplasm with the centrally suspended nucleus is not suggested by the drawing and was not noted in the description. It seems to me that Carter's failure to observe any details of the segmentation of the gonidia and development of the resulting embryos was probably due to lack of observations made on the living material late in the afternoon or in the night.

Antheridial or oogonial daughter coenobia were observed by Carter in mother coenobia containing also gonidial daughters. Oogonia and antheridia were not found in the same coenobium, nor were daughter coenobia of both sexes found in the same parent.

In single parents one, two, three, and even all, of the progeny were male. They were never more than half of the size of the asexual daughters. The antheridia numbered upward of one hundred in each male coenobium, and were scattered indiscriminately over the whole of the internal periphery.

The androgonidia (called spermatic cells) were described as reaching a diameter of 40 μ, his fig. 8 *a* (Plate 8, fig. 48). They underwent division to form, each, a circular, tabular group of linear ciliated sperms arranged vertically upon the same plane. The spermatozoids were supposed to number one hundred twenty-eight in each platelet. The surface-view drawing, his fig. 10 *b* (Plate 8, fig. 49 *b*), which was cited for illustration of the antheridium of this species represents about ninety-three sperms. It is to be noted that the same drawing is used for illustration of the other species that was described in the same paper.

The spermatozoids were described as linear, horn-shaped, about 11 μ long; anteriorly attenuated and colorless, posteriorly greenish; provided with a pair of cilia which are attached to the anterior extremity, and with an eyespot some distance back of the tip (Plate 8, fig. 50 *a*, *b*, *c*). The progression of the spermatozoids was described as "vermicular from their extreme plasticity." The antheridial coenobia were liberated after the spermatozoids had been formed, but before they had become separated.

Oogonia were observed to be present instead of gonidia in two, three, or even all, of the eight daughters in asexual coenobia. In such female daughters the oogonidia numbered from thirty to fifty and were scattered indiscriminately over the posterior three-fourths of their respective coenobia. The oogonidia were two or three times the size of the somatic cells and of a light greenish color, while the daughters remained within the parent. They became still more enlarged and of a deep dark green color a short time after the daughters had been liberated.

After fertilization the oospores became surrounded by a thickened spore wall, which appeared to be "slightly wavy in its outline." The spore wall shown in his fig. 7 *a* (Plate 8, fig. 47) depicting one of these spores is characterized by Stein ('78, p. 134) and by Klein ('89A, p. 196) as being slightly toothed. The diameter of the oospores was given as about 40 μ, and the drawing of it measures about 42 μ.

MERRILLOSPHAERA CARTERI VAR. WEISMANNIA (POWERS) COMB. NOV.

Powers's description ('08, pp. 152 to 162, 172 to 175) under the name *Volvox weismannia* of material collected by Professor Wolcott at Rocheport, Missouri, will now be recast for the purpose of comparison. The data will be taken from his photomicrographic figures when they are not supplied by his text. It is to be noted that Powers wrongly called the gonidia ova.

The form of the adult coenobium is obviously, from the figures, spherical, or nearly so. The largest nearly mature asexual coenobium (his fig. 46) measure about 664 by 672 μ, and two others of about the same maturity (his figs. 37 and 55) both measure about 580 by 605 μ. The size of the coenobia at the time of segmentation of the gonidia is indicated by an 8-gonidiate coenobium (his fig. 36) in which the gonidia show a radial flattening which is the first sign of segmentation. It measures about 350 μ. A 10-gonidiate coenobium (his fig. 39), with the gonidia not yet showing signs of dividing, measures about 400 μ. No free sexual coenobia are shown. The size of the daughters before birth reaches, as appears in his fig. 55, more than 190 μ, the gonidia measuring at that time more than 22 μ in diameter. So far as can be seen in the figures, the gonidia of the daughters before birth are about equal in size in the same daughter. This probably holds true mainly in cases in which the gonidia occur in the typical number, eight.

The number of somatic cells in the coenobia was not stated by Powers. Estimates of the number of cells in the coenobia shown in ten of his figures, based on counts of cells in small, centrally located areas,[5] with no allowance for the error due to the flattening of the coenobia for photography, give numbers ranging from 2,500 to 7,500, numbers coming between the 11th and 13th powers of 2, in which class the real numbers probably belong. Powers did not describe the somatic cells. His figures show the distance between the protoplasts to be greatest at the anterior pole and to diminish progressively toward the posterior pole, where it is least, the ratio of the intercellular distances at the opposite poles being, for example, in a nearly mature asexual coenobium (his fig. 46) nearly 2 to 1.

The number of gonidia (which Powers erroneously called ova, occasionally referring to them as primary sex cells) in the asexual coenobia he stated to be, most commonly, eight and ten, the latter number predominating. Less frequently, he stated, there are twelve. Odd numbers also occur.

The gonidia are differentiated from the somatogenic cells at about the 64-celled stage of the embryonic development; or, if not, certainly at the next step. They are large globular cells, which attain diameters of about 25 μ before birth (his fig. 37), and as great as 90 μ before segmentation (Powers, '08, p. 156), the largest that was figured (his fig. 41) being about 65 μ in diameter. They appear to be multivacuolate with a central nucleus.

The arrangement of the gonidia is almost mathematically regular. When the number is eight the arrangement is simplest and symmetrical; four lie equidistant from one another near the periphery of a transverse plane considerably anterior to the equator of the coenobium, the four others lie in the periphery of a transverse plane well toward the posterior pole and alternating with the members of the anterior quartet. When ten are present, two are usually uniformly smaller and placed between the second quartet and the posterior pole on opposite sides of the polar axis in positions more or less nearly opposite to members of the anterior quartet. When twelve are present there are two quartets of larger gonidia and a posterior quartet of smaller gonidia. Deviations in the number of gonidia occur by the omission of one or more members of one or more of the quartets or pairs. In such cases the remaining members retain their typical places.

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[5] The estimates were made by applying the formula, $N = \frac{n}{c} D^2$, in which N is the total number of peripheral cells, D the diameter of the coenobium in microns, n the number of cells counted in a selected area, and c a constant, representing $\frac{a}{\pi}$ in the formula, $N = \frac{\pi D^2 n}{a} = \frac{n}{\frac{a}{\pi}} D^2$, in which a is the area used for the counts. In this case the constant, c, was given a value of 1,000 by taking an area of 3,141 square microns. The radius of a circle having this area, multiplied by 79, the indicated linear magnification of the figures, was used for cutting a hole in a card which was placed over the figures for the counts. The diameter of that hole was about 5 millimeters.

The segmentation of the gonidia was not described, and the radial flattening of the gonidia which precedes segmentation was not recognized as such but was noted as a character of the "ova," that is, the gonidia. The account of the embryonic metamorphosis is so involved with an account of an invagination and inversion process that it is impossible to decide what of it is pathological and what of it, if any, is misinterpretation of stages of normal development. Instances of invagination in young but completely closed coenobia were sought by Powers ('08, p. 160), but not found.

The male coenobia were called dwarf male colonies. Powers records having observed one hundred thirty-one parental coenobia bearing recognizable male progeny. The number of males in a parent varied from one to ten. The progeny were exclusively male in only one instance, the one shown in his fig. 57. The unborn male coenobia are about equal in size to their unborn asexual sisters, about 210 μ in diameter. They are dwarf only in the sense of having no postnatal growth. It was stated that the sperms were ripened before the male coenobia were liberated. The number of somatic cells is small in proportion to the number of androgonidia. The sperms are formed in tabloid bundles of sixty-four and one hundred twenty-eight. The two sizes occur side by side. The sperm bundles are slightly concave, presumably on the posterior, nonciliated side. The spermatozoids are slender and have terminal cilia.

So far as it relates to female coenobia and to real oogonia Powers's account is almost blank. This fact may have a significant bearing on the consideration of Klein's account of the material collected by Migula, which is to be taken up in the next section of this paper. In Powers's inventory of the contents of twelve coenobia he records that one daughter of No. 2 had "sixteen reproductive cells of half the size" as compared with those of its nearest sister, and No. 4 contained a "typical daughter with 18 or 20 reproductive cells." I take these to be real female daughters. Embryonic female coenobia are probably shown in his figs. 30 and 47, in which the reproductive cells, it was stated, are "probably 18 or 20" and "double the [usual] number of reproductive cells," respectively. Of the latter case Powers said: "Their position in pairs may be partially noted; also their size reduced by one-half."

No free stages of the female coenobia were described, and likewise no oospores.

MERRILLOSPHAERA MIGULAE SP. NOV.

Klein's description, under the name *Volvox aureus* ('89B), of material that had been collected and prepared by Migula in Karlsruhe, Germany, was probably less complete than it might otherwise have been, partly as a result of the treatment of the material as a mere form of a species which Klein had recently described in great detail, and partly as a result of being represented by preserved material only. The most important part of this description consists of the figures of eight coenobia with various contents. The first figure shows a coenobium which differs from typical *Merrillosphaera carteri* in being smaller, having a smaller number of somatic cells, and having the protoplasts of the latter somewhat more elongated. More-marked differences are apparent in other figures.

Before we attempt to summarize the characters of the coenobia described we have to consider the possibility or probability that certain misinterpretations were incorporated in the description. In one of the figures (Klein '98B, fig. 7) the neighboring somatic protoplasts are shown connected by proptoplasmic filaments of the kind that is characteristic of *Volvox aureus*. Since Klein definitely stated that such connecting filaments were not visible in the preparations, the drawing evidently shows more than was visible. This leads me to question whether the four reproductive cells in this coenobium, and similar cells in five other coenobia, that were called, by Klein, "recently fertilized eggs" and drawn with very distinct and apparently thickened walls, were properly interpreted and correctly drawn. In view of the unquestionable fact that such a misinterpretation was made by Powers ('08) when he called the gonidia "ova," it is not unthinkable that such an error should have been made by Klein.

Apparently an absence of female coenobia in advanced stages of development in Powers's material was a cause contributing to the error in his case, and a similar condition of the material used by Klein may have contributed to the same error in his work. Nevertheless, the simplest hypothesis for us to adopt for the purposes of the present discussion is that the large reproductive cells present in several of Klein's coenobia were in some cases gonidia, and in others the nearly ripe and the recently fertilized eggs that he called them.

The form of the coenobium in four of Klein's figures is nearly spherical, and in the other four decidedly ovoid. The dimensions[6] were given for six of the coenobia. Assuming that all of the drawings are on the same scale[7] I have measured those for which he did not give figures and here give the dimensions of all the coenobia in the order of the figure numbers: 290 by 325 μ, 345 μ, 270 μ, 225 by 260 μ, 320 by 380 μ, 290 μ, 300 μ, and 320 by 425 μ. Of the spherical coenobia, two are practically isodiametric and two are very slightly elongated. It is the polar axis, if any, that is the longer.

The somatic protoplasts were represented as round in surface view and ovoid in median optical section views of the coenobia. It was stated that the cilia were not visible under the magnification that was used for making the drawings. Measurements of the vegetative cells, by which I understand Klein to mean protoplasts, were given for all of the coenobia as follows, in the sequence of the figure numbers: 7.3 to 7.5 μ, 6.4 to 7.3 μ, 6.5 μ, 7.3 to 8.9 μ, 7 to 7.5 μ, 7.3 to 8 μ, 6.4 to 7.3 μ, and 6.4 μ.

The somatic protoplasts are farther apart at the anterior pole and the spacing is graded from one pole to the other in the drawings of all but one or two of the smaller coenobia.

The number of somatic cells present was stated by Klein for all of the mother coenobia except that of his fig. 4. I have assumed that these numbers were obtained by a method which Klein stated in his first paper ('89A, p. 146). The formula used in that procedure made no allowance for the fact that the areas occupied by the individual cells are[8] proportional to the areas of hexagons having diameters equal to the intercellular distances rather than to squares having the same diameters. Hence the numbers should be larger than given, by about 15 per cent. The numbers thus revised are, respectively: 1610, 1440, 1440, —, 2180, 1675, 1675, and 2080.

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[6] The figure 260 given for the shorter dimension of the first coenobium is obviously a misprint for 290.

[7] The scale is evidently about 152 diameters, and not 120 as stated in the explanation of the plate.

[8] As was pointed out by Janet ('12, p. 28).

The numbers of reproductive bodies present in the coenobia are 8, 11, 10, 9, 9, 10, 10, and 3, respectively. In the latter case, that of the largest coenobium, the maturity of the daughter coenobia present is such as to suggest that other daughter coenobia might have been already discharged from the mother. In all of the mother coenobia reproductive bodies are lacking in the anterior third and confined to the other two-thirds. In two coenobia the only reproductive bodies are daughters, in four they are a mixture of reproductive cells and daughters, and in the remaining two they are reproductive cells alone. These reproductive cells are mostly large, round cells with a doubly defined wall, about 55 μ in diameter, which Klein called recently fertilized eggs. In one coenobium four of these so-called fertilized eggs are accompanied by five similar cells, somewhat smaller and without the double wall, which Klein called nearly ripe eggs. Granting that these be in reality eggs and oospores, we have here a distinct species of *Merrillosphaera*. Were they resting spores developed from gonidia, we would have a distinct variety of *M. carteri;* but if they be, as I am not now inclined to believe, merely asexual gonidia that, for one reason or another, were mistaken for eggs, then the variety is hardly distinct.

The first coenobium on the plate illustrating this variety (Klein, '89B, fig. 1) is one with eight nearly equal daughters almost perfectly symmetrically arranged in two quartets.[9] One member of each quartet is a male coenobium containing androgonidia which are shown in the first and second stages of division. These male coenobia are of about the same size, 80 to 90 μ, and shape as their sisters. The latter were called female daughter colonies. It seems to me more likely that they were in reality asexual daughters. Each of them contains a small number of relatively large reproductive cells measuring 18 to 20 μ. In four daughters that are entirely visible the numbers of the reproductive cells shown are 6, 6, 7, and 8. It is not likely that the number present in any case was beyond the range of variation in the number of reproductive bodies in the mother coenobia of the preparations, for in such a case it would have attracted Klein's attention and been the subject of special remark. There is, then, no reason for regarding these daughters as other than asexual daughters, each containing well-developed gonidia, in number about the same as the eight of the mother within which the daughters were developed.

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[9] A coenobium almost exactly like this one is represented diagrammatically by Janet ('12, p. 117) in his fig. 14, D, under the name *Volvox aureus*. It contains three male coenobia and five asexual daughters that are mislabeled female coenobia, each of the latter containing eight or nine gonidia that are labeled gynogonidia. There is nothing in this figure essentially different from typical *Merrillosphaera carteri.* Janet's fig. 14, F, is evidently *M. migulae* with a combination of reproductive bodies not duplicating anything that was figured by Klein. In this also gonidia are labeled gynogonidia, as they are likewise in his fig. 14, E.

In the largest, which is evidently the most mature coenobium (Klein, '89B, pl. 3, fig. 8), from which I venture to suppose that some of the progeny had departed, there are present one male coenobium and two other coenobia which were called female. The male coenobium is fully mature, about 103 μ in diameter, and contains about two hundred thirty cells[10] including about sixty ripe spermatozoid bundles, each about 12.5 μ wide. The so-called female coenobia measured 115 and 135 μ in diameter, have vegetative cells about 4.3 μ in diameter and reproductive cells, called eggs by Klein, that are 22 to 25 μ in diameter. The numbers of the latter shown in the figure are seven and nine. These numbers are probably the total numbers found present rather than the numbers of the reproductive cells seen in the nearer hemisphere of each daughter, for the reason stated in the preceding paragraph. There is nothing about them to mark them as female.

In the four mother coenobia containing mixtures of reproductive cells and coenobia, there are altogether ten male coenobia and ten of the kind which Klein called female, but which I regard as possibly asexual. Of the six coenobia that contain progeny, five contain males and the other one contains but a single coenobium. Carter ('59) remarked, as I have already stated, that he found males and asexual coenobia in the same mother, females and asexual coenobia in the same mother, but never male and female in the same parent. A similar state of affairs in the coenobia of *M. migulae* would account for the absence of any female daughters in the coenobia figured, for there is but a single daughter in all of them that is not accompanied by male coenobia.

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[10] Including the 15 per cent which I add to Klein's estimates for the reason stated on page 111.

Were I to treat this form as a variety of *M. carteri* I would be assuming that the female coenobia of the variety contain a much larger number of reproductive cells than are contained in the asexual coenobia. This would involve the assumption that no female coenobia are shown in the figures or described, and that the so-called eggs are in reality very large gonidia. Granting that the so-called fertilized eggs are actually such, then the variety has no place in *M. carteri*, but stands as a separate species of the genus.

Male coenobia of the kind found and described in Migula's preparations were observed by Klein ('90, p. 27) in the collections of the following season almost to the exclusion of another form of male coenobium which Klein had previously described for what he considered to be the same species, namely, *Volvox aureus*. After recognizing the occurrence of two forms of male coenobia, he observed that, though either form might be met with at any time during the vegetative season, as long as sexual coenobia were being formed, from May to November, nevertheless the two forms almost never occurred simultaneously in the same habitats, and when, in exceptional cases, they were so found together, it was in each case only for a short time. The male coenobia that he had described in his first paper he called, in drawing a distinction in his third paper, "normal, typical, large *Sphaerosirae*." He called them normal and typical because he took them to be like the material on which the former genus *Sphaerosira* was founded by Ehrenberg ('38).[11] The male coenobia of the kind found in Migula's preparations he called "small *Sphaerosirae*" and he further distinguished them by the name *Endosphaerosira*. The normal *Sphaerosira* averaged 350 to 450 μ in diameter and was found to reach even 750 μ. The androgonidia in this form were hardly distinguishable from the vegetative cells at the time of birth, and the development of the antheridia was correspondingly late. The *Endosphaerosira*, on the other hand, was invariably smaller, usually between 100 and 150 μ in diameter, and commonly ripened its antheridia before birth, or at least had its androgonidia segmented at that time. It also contained a much smaller number (120 to 140) of vegetative cells than the normal *Sphaerosira*, though the number of antheridia (60 to 70) was relatively larger. Klein's figure of an *Endosphaerosira* ('90, fig. 32) shows a coenobium very similar to the male coenobium which Carter, in his fig. 8 *a* (Plate 8, fig. 48), had depicted in a somewhat different style and with less skill. It appears probable to me that the *Endosphaerosira* of Klein was improperly assigned to *Volvox aureus*, and that it belongs rather to one or more of the species of the genus *Merrillosphaera*.

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[11] Klein ('90, p. 82) called attention to the fact that De Toni ('89, p. 536) erroneously assigned *Sphaerosira volvox* Ehrenb. to *Volvox glabator* Ehrenb., whereas it is the male coenobium of *V. aureus* Ehrenb.

The sperm bundles of the *Endosphaerosira*, according to Klein, contained invariably thirty-two spermatozoids.

MERRILLOSPHAERA TERTIA (MEYER) COMB. NOV.

When Meyer ('96) was working with material that he had collected at Marburg, Germany, and that he named *Volvox tertius* he, apparently, had not seen Klein's second *Volvox* paper ('89B), for he made no mention of it in either his text or his list of references. The characters appearing in Meyer's meager description, by which his material is distinguishable from Migula's material as described by Klein, are four: First, the occurrence of smaller numbers of reproductive bodies, which ranged from four to eight in a coenobium, as compared with eight to eleven; second, the occurrence of oospores in numbers greater than the numbers of asexual reproductive bodies, which were recorded as ten, twenty, and thirty, associated with four, five, and three asexually produced daughters, respectively; third, the restriction of the antheridia to the reproductive hemispheres of the male coenobia; and, fourth, the fact that in some daughter coenobia the gonidia had begun to divide while the daughters still remained within the mother coenobia. The latter point is shown by the following statement in Meyer's ('96, p. 190) text:

> * * * Die anfangs stets hellgrünen Zellen *e*? beginnen sich theilweise schon in den Tochterkugeln zu theilen, können aber auch in der Tochterkugel bis ungefähr 50 μ gross werden, ohne sich zu theilen, und sich erst theilen, wenn die Tochterkugel frei wird. * * *

The ranging of the number of asexual reproductive cells downward from eight, and the segmentation of some of the gonidia before the birth of the coenobia containing them, are characters by which Meyer's species approaches *Volvox africanus* West ('10). The occurrence of oospores in the numbers ten, twenty, and thirty is indicated only by numbers in Meyer's table of combinations of reproductive bodies found in coenobia. The data given in that table have been rearranged in Table 1 given herewith, and the three cases indicated by the letter *G* constitute the only information given about the ten, twenty, and thirty oospores.

TABLE 1.—*Combinations of reproductive bodies reported by Meyer to have been observed in his Volvox tertius, with his index leters.*

Index letter.	Daughters with segmented gonidia.	Daughters with reproductive cells.	Daughters with antheridia.	Oospores.	Total reproductive bodies.
A	----	----	----	6	6
C	----	6, 7, 8	----	----	6 to 8
D	4, 5, 6, 8	----	----	----	4 to 8
G	4	----	----	10	14
G	5	----	----	20	25
G	3	----	----	30	33
I	4	----	1	----	5
I	5	----	1	----	6
I	6	----	1	----	7
I	4	----	2	----	6
I	5	----	2	----	7
I	2	----	4	----	6
K	3	2	----	----	5
K	5	2	----	----	7
K	4	3	----	----	7
K	1	4	----	----	5
K	2	5	----	----	7
NB	4	----	1	1	6
NB	----	2	1	2	5

Meyer did not state the number of times that the different combinations were found, nor did he indicate whether any of the numbers or combinations of numbers were met with more frequently than others. I am inclined to regard his case *A* as another in which gonidia were mistaken for eggs or oospores on account of their great size. Likewise the one and two oospores of his *NB* cases.

Meyer's attention at the time when he described this species was directed more especially to the subject of intercellular protoplasmic connections and cell membranes. His new species differed from two species of *Volvox* in which he had made a detailed study of those connections and membranes. It entirely lacked the protoplasmic connections between the protoplasts of the adults, though such connections were said to be readily visible between the cells of living, unborn daughter coenobia (Meyer, '96, p. 200, pl. 8, fig. *a*). It differed from the other species also in the form of the membranes of the somatic cells. His diagrammatic drawings, based on careful study of stained material, are reproduced herewith as text fig. 1. The protoplasts are shown globose in form, about 7.5 μ in diameter (Meyer, '96. pl. 8, fig. *z*), and separated each from its own outer membrane *m* by a thick gelatinous wall *w*. The space within the outer membrane of a typical cell is hemispherical in its outer half and hexagonally prismatical in its inner half, with a somewhat convex inner side. The protoplast is well within the outer half of the space. The outer membranes of the prismatical portions of neighboring cells are united to form what has the appearance of a middle lamella that is thickened at the corners *k*. A peripheral membrane *p* of the coenobium covers an intercellular space system *o*, that is filled with an intercellular substance, between the hemispherical parts of the somatic cells.

The gonidia were described as reaching diameters as great as 50 μ, and dividing either before or after the birth of the coenobia containing them. Cells similar to the gonidia were said to become dark green and become transformed into oospores when they reached diameters of 40 to 50 μ. The fertilization was supposed to take place while the coenobia containing the eggs were still within their mothers. The antheridia were produced in the reproductive halves of the male coenobia. The androgonidia segmented when 13 μ in diameter. Each produced a hemispherical or tabular bundle of spermatozoids while the male coenobium was yet within its mother. The oospores that were supposed to have been seen were described as having smooth walls.

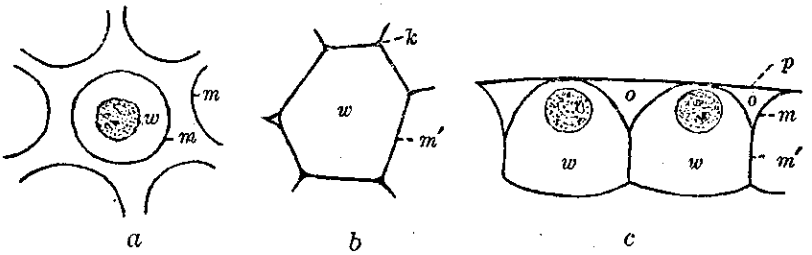

FIG. 1. Protoplasts and membranes of the body cells of *Merrillosphaera tertia* (Meyer) Shaw. *a*, tangential optical section at about the level of the middle of the outer half of the cell; *b*, similar section at about the middle of the inner half of the cell; *c*, diagrammatic radial section through body cells. The peripheral lamella, *p*, of the coenobium covers the intercellular space, *o*, filled with an intercellular mass, between the outer lamellae, *m*, of the neighboring body cells. Each protoplast is separated from the outer lamella of its wall by a thick gelatinous wall, *w*. After Meyer.

Fuller accounts of both *Merrillosphaera migulae* and *M. tertia* will be needed before we shall be in a position to make a final decision as to whether the organisms represented by these names properly belong in the same or in different species. With our present unsatisfactory data it is useless to attempt to predict what the ultimate systematic disposition of these forms will be. Therefore, so long as the proper status of each continues problematical, it seems more conducive to an early solution of the problems to treat them separately.

MERRILLOSPHAERA AFRICANA (WEST) COMB. NOV.

The species described by West ('10 and '18) from Africa under the name *Volvox africanus* was found in such abundance and variety about Manila that it seems desirable to reserve the description of the Philippine material for another paper. There is also in some of my material a form that is in some respects intermediate between *M. africana* and *M. carteri* that will require more study before I can decide whether to treat it as a separate species or as a variety or form of *M. africana*.

The characters that bring *M. africana* into the genus are the absence of connecting filaments between the somatic protoplasts and the large size of the gonidia that are differentiated very early in the development of the coenobium.

The characters that distinguish this species from *M. carteri* are: Coenobia smaller and ovoid; number of cells smaller; gonidia one to four, in pairs, the members of the hinder pair smaller, differentiated very early and dividing early, generally before the birth of the coenobium and often before the birth of the mother coenobium.

A diagnosis of the species based on West's description will be given after the diagnosis of the other species in a later section of this paper.

DIAGNOSES OF GENUS, SPECIES, AND VARIETIES

Genus **MERRILLOSPHAERA**[13] novum

(*Volvocaceae, Volvoceae*)

Body a spherical or ovoid coenobium of biciliate cells which contain chloroplasts. The cells appear to lie in the periphery of a gelatinous matrix surrounded by a hyaline envelope through which the cilia extend. Somatic protoplasts globose or ovoid, each inclosed in a thick gelatinous membrane which is more or less prismatic in form. No protoplasmic filaments connecting the protoplasts. Asexual reproduction by gonidia, differen-

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[13] This name was first published in a footnote (Shaw, '19, p. 512) in a number of the Philippine Journal of Science that was issued March 30, 1920.

tiated in early embryonic stages,[13] which sink from positions in the layer of somatogenic cells into positions directly within the coenobium. They develop to relatively large size before segmentation. Sexual reproduction by oospores formed from oogonidia which are smaller and more numerous than the gonidia and usually borne in female coenobia, and antheridia formed from androgonidia which are smaller and more numerous than the oogonidia and borne in male coenobia. Antheridia in the form of sperm bundles or platelets that may be more or less cupped. Spermatozoids elongate, probably with terminal cilia.

The type species of this genus is *Volvox carteri* Stein, based on *Volvox globator* Carter, non Ehrenberg, described by Carter in Bombay, India. The first variety of the species to be described in sufficient detail to supply the essential diagnostic characters of the genus is *Merrillosphaera carteri* (Stein) Shaw var. *manilana* Shaw, described in this paper from material collected about Manila, Philippine Islands. Other forms are: Var. *typica* Shaw based on Carter's description of the Bombay material; var. *weismannia* (Powers) Shaw based on *Volvox weismannia* Powers described from material obtained in Missouri, North America; and species *migulae* Shaw based on the description by Klein under the name *Volvox aureus* of material obtained from Karlsruhe, Germany.

Other species are: A somewhat doubtful one, *Merrillosphaera tertia* (Meyer) Shaw (*Volvox tertius* Meyer) described from Marburg, Germany, and *M. africana* (West) Shaw (*Volvox africanus* West) described from Albert Nyanza, Africa, and reported by Shaw from the Philippine Islands.

MERRILLOSPHAERA CARTERI (Stein) comb. nov., var. **TYPICA** var. nov. Plates 7 and 8.

Volvox globator Carter, non Ehrenberg, in Ann. & Mag. Nat. Hist. III 3 (1859) 2–5, 18, 19, *pl. 1, figs. 1, 3, 4, 7, 8, and 10.*

Volvox carteri Stein in Der Organismus der Infusionsthiere. Leipzig 3[1] (1878) 134.

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[13] It might more properly be said that the somatogenic cells are differentiated from the gonidia at a very early stage of the embryonic development of the coenobium, and that they become distinguishable by continuing to divide while the reproductive cells cease dividing and begin to grow. The view expressed by Harper ('18, p. 163) that *Volvox* "shows vegetative totipotence and equivalence of its cells in the growth of the colony" is obviously not applicable to any of the species of *Merrillosphaera*. Moreover, it appears likely that the gonidia in the latter genus will be found to be representative of segments in the 8- or 16-celled stage of development, and that they become differentiated when those segments have further divided two or three times.

Coenobia spherical; asexual reaching a diameter of 770 μ; female, 610 μ; and male, 270 μ. Number of somatic cells not stated; protoplasts globose, of size not stated. Gonidia generally 8, all in a coenobium of about the same size and confined to the posterior three-fourths of the coenobium; arrangement not noted. Size of gonidia at time of differentiation not noted; reaching 40 μ in daughters of about 195 μ before the birth of the daughters; attaining a diameter of 85 μ before dividing; chloroplast forming a peripheral network within the gonidium. Asexual daughters formed alone, with female daughters, or with male coenobia in the same mother coenobium. Male and female coenobia not observed in the same mother. Oogonidia 30 to 50, distributed in the posterior three-fourths of the female coenobium; reaching two or three times the size of the somatic cells in daughters yet unborn. Oospores about 40 μ in diameter, with the thickened wall "slightly wavy in its outline" or wavy toothed. Androgonidia upward of 100, scattered over the whole internal periphery of each male coenobium; reaching 40 μ in diameter; producing antheridia before the birth of the male coenobium. Antheridia consisting of platelets of 128 (?) sperms. Each spermatozoid with a pair of terminal cilia and a lateral stigma; spermatozoids liberated after the birth of the male coenobium.

Habitat.—A pool in Bombay, India (*leg.* H. J. Carter, 1858).

MERRILLOSPHAERA CARTERI (Stein) Shaw var. **MANILANA** var. nov.
Plates 1 to 6.

Coenobia spherical or slightly elongated; asexual reaching about 720 by 760 μ; female, about 690 by 730 μ; and male, about 260 by 280 μ. Number of somatic cells in asexual coenobia as high as 11,400; in female coenobia, 8,000; and in male coenobia, 2,500; commonly much fewer. Somatic protoplasts ovoid, about 5 to 6 μ thick. Gonidia 8, about equal in size, arranged symmetrically, 4 in front of, and 4 behind, the equator, sometimes with 1 to 4 additional, somewhat smaller gonidia nearer the hinder pole. Gonidia in very young coenobia about 17 μ in diameter; reaching at time of birth about 24 μ, and at maturity about 85 μ. Asexual daughters reaching about 200 μ diameter at time of birth. Male coenobia producing about 112 androgonidia. Androgonidia reaching about 16 μ; dividing before birth of the male coenobium to form sperm platelets that are more or less cupped. Female coenobia producing about 24 to 40 oogonia (oogonidia) of which none is in the front part of the coenobium. Oogonidia about 14 μ in diameter in coenobia of about 175 μ diameter at time of birth. Oospores about 50 μ in diameter; with very slightly wavy wall about 2.5 to 3 μ thick; with eccentric protoplast about 37 μ wide.

Habitat.—Fresh-water pools, near Manila, Philippine Islands (*leg.* W. R. Shaw 1914).[14]

MERRILLOSPHAERA CARTERI (Stein) Shaw var. **WEISMANNIA** (Powers) comb. nov.

Volvox weismannia Powers in Trans. Am. Microscop. Soc. 28 (1908) 141–175, *pls. 24–26, figs. 25, 27–61.*

Coenobia spherical or nearly so; asexual reaching at maturity 664 by 672 μ; at time of segmentation of the gonidia 350 to 400 μ. Mature females not described. Male coenobia about 210 μ in diameter. Somatic cells 2,500 to 7,500; form and size not stated; intercellular distances not given, but greatest at anterior pole and grading to about half as great at the posterior pole. Gonidia 8 to 12, most commonly 10; differentiated at the 64-celled or the next stage, reaching 25 μ before the birth of the coenobium containing them and 90 μ (the largest figured was 65 μ) before segmentation. Gonidia arranged regularly in two quartets, without or with an additional pair or quartet of smaller ones from which members may be absent; occupying the posterior three-fifths of the coenobium. Female coenobia described only in very young stages within their mothers. Oogonia differentiated at an early embryonic stage; twice as numerous (16 to 20) as the gonidia. Male progeny in parental coenobia 1 to 10; before birth about equal in size to their asexual sisters. Androgonidia more numerous than oogonidia; scattered around the internal periphery of the male coenobia segmenting into antheridia and forming tabloid bundles of 64 and 128 sperms that ripen before the birth of the coenobia containing them. Spermatozoids slender, with terminal cilia. Oospores not described.

Habitat.—A broad, shallow pond near Rocheport, Missouri, North America (*leg.* Wolcott, 1904).

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[14] Slide mounts of material of this species from the vicinity of Manila have been sent to Prof. Frank G. Haughwout, Bureau of Science, Manila, and to Prof. Douglas H. Campbell, Stanford University, California. Material bottled in glycerine has been sent to sixteen biologists in America and to sixteen in Europe and Asia. Duplicates of this bottled material are available for distribution from my American address: Claremont, California.—W. R. S.

MERRILLOSPHAERA MIGULAE sp. nov.

Volvox aureus Ehrenberg, Klein, in Ber. d. deutschen bot. Ges. 7 (1889) 48–53, *pl. 3, figs. 1–10;* and in Ber. d. naturf. Ges. Freiburg i. B. 5 (1890) reprint 23 and 24, 27 and 28, *pl. 2, fig. 4, pl. 4, fig. 32.*

Coenobia spherical or ovoid; asexual usually between 250 and 350 μ, reaching 320 by 425 μ; female similar; male averaging 100 to 150 μ. Number of somatic cells, 1,440 to 2,180. Protoplasts ovoid, about 7 to 8 μ in diameter. Gonidia 8, sometimes more; sometimes of uniform size and arranged in two quartets; attaining diameters of 25 μ before birth of the coenobia containing them, and probably 62 μ before segmentation. Some coenobia with gonidia and oogonidia. Female coenobia with about 8 oogonidia. Asexual, male, and possibly female coenobia formed in the same mothers, and of about the same size at time of birth. Antheridia, consisting of sperm platelets of about 12.5 μ diameter, containing 32 spermatozoids, commonly mature before birth of the male coenobia. Oospores with smooth walls, 52 to 62 μ in diameter.

Habitat.—Karlsruhe, Germany (*leg.* Migula, 1888); Buchheim, Alt-Breisach, Hochdorf, Germany (*leg.* Klein, 1888?).

MERRILLOSPHAERA TERTIA (Meyer) comb. nov.

Volvox tertius Meyer in Bot. Zeit. 54^{1} (1896) 188–191, 200–201, 216–217, *pl. 8, figs. A, Z* and *a, text figs. 5–7.*

Form and size of coenobium not stated. Number of somatic cells not given. Somatic protoplasts globose, about 7.5 μ. Membranes of somatic cells (described very particularly) hemispherical and of a thickness equal to about one-sixth of the diameter of the protoplast on the outer side, and prismatic and of a thickness equal to about one and a half times the diameter of the protoplast on the inner side. Gonidia 4 to 8 in the asexual coenobia; attaining diameters as great as 50 μ and dividing either before or after the birth of the coenobia containing them. Female coenobia doubtful. Three coenobia were reported to contain 4, 5, and 3 asexually produced daughters and 10, 20, and 30 oospores, respectively; that is, gonidia and oogonidia in the same coenobium. Oogonidia said to form oospores when they reach diameters of 40 to 50 μ. Androgonidia produced in reproductive half of male coenobium; reach 13 μ diameter; produce hemispherical or tabular bundles of sperms before the birth of the male coenobia. Oospores said to have smooth walls.

Habitat.—A pool near Marburg, Germany (*leg.* Meyer, 1895?).

MERRILLOSPHAERA AFRICANA (West) comb. nov.

Volvox africanus West in Journ. Quekett Mic. Club II 11 (1910) 102–103, *pl. 3, figs.* 8–10; and II 13 (1918) 425–428, *pl. 29, figs.* 4–6.

Coenobia ovoid; ranging from 295 by 345 μ to 480 by 610 μ. Number of somatic cells between 3,000 and 8,000. Somatic protoplasts almost globose, 8 to 9.5 μ in diameter; about 25 μ apart at anterior pole, and grading to much smaller distances at posterior pole. Gonidia 1 to 4; arranged more or less in pairs; gonidium or pair of gonidia near posterior pole smaller than the others and producing smaller daughters. Gonidia of the daughters in some cases divide and produce granddaughters containing gonidia that are the beginning of the fourth generation while the daughters are still within their mother. Daughter coenobia strongly ovoid and more or less flattened by mutual pressure; granddaughters spherical. Female coenobia with 70 to 80 oospores (average 74); oospores with thick smooth walls, average diameter 45 μ. Description of male coenobium not yet published.

Habitat.—Albert Nyanza, Africa (*leg.* R. T. Leiper, 1907); Ussangu Desert, German East Africa (*leg.* A. W. Jakubski, 1909–10); fresh-water pools near Manila, Philippine Islands (*leg.* W. R. Shaw, 1914).

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ILLUSTRATIONS

[Photomicrographs of *Merrillosphaera carteri* (Stein) Shaw, from specimens mounted in glycerine except as otherwise noted, taken by W. R. Shaw and E. Cortes at the Bureau of Science, Manila.]

PLATE 1

FIG. 1. Type specimen of *Merrillosphaera carteri* var. *manilana.* A coenobium with eight embryo daughters. × 100.

2. A portion of the coenobium wall and one of the embryo daughters of the same specimen as that shown in fig. 1. The embryo shows in profile two protruding gonidia. × 200.

3. A mature asexual coenobium of the same variety as fig. 1, containing eight female daughters. In four of the daughters the oogonidia counted are 24, 27, 31, and 37. × 100.

4. A nearly mature female coenobium with twenty-nine oogonidia. × 100.

5. A mature asexual coenobium somewhat flattened under a cover glass. It contains four asexual daughters and three male offspring. The daughters contain eight gonidia each, and the male coenobia each about one hundred twelve androgonidia that are mostly undivided in the hindmost one and mostly 2- or 4-celled in the two others. × 100.

6. A young coenobium with eight gonidia that are 24 to 27 μ in diameter. × 100.

7. A male coenobium with the reproductive bodies developed into sperm platelets that are more or less cupped. × 100.

PLATE 2

FIG. 8. A mature asexual coenobium of *Merrillosphaera carteri* var. *manilana* with eight asexual daughters, each with eight gonidia so far as could be counted. × 100.

9. An asexual coenobium of the smaller form. It has nine gonidia that measure 53, 55, and 46 μ. × 100.

10. A young asexual coenobium of the smaller form. It contains twelve gonidia very symmetrically arranged. In the forward group two are in the middle of the picture, in the second group two are at each side, and in the hindmost group two are near the middle of the picture. The gonidia of the third group are about 28 μ wide, and the others about 32 μ. There is a noticeably large gap between the second and third groups of gonidia. × 100.

11. An asexual coenobium with only six gonidia. They are symmetrically arranged in a group of four just ahead of the middle, and a pair halfway back from them to the hinder pole. They all measure about 50 to 53 μ. × 100.

12. A mature asexual coenobium with eleven asexual daughters arranged in two symmetrical groups of four, one just ahead of, and the other just behind the middle, and three members of a hypothetical group of four smaller daughters just back of them. × 100.
13. An asexual coenobium with eight gonidia in process of division. The first three in the upper row and the second and fourth in the lower row are 2-celled. The others are 4-celled. This is from the same collection as the specimens shown in Plate 1, fig. 5, and Plate 4, fig. 24. × 100.
14. An asexual coenobium of the smaller form. It has eight symmetrically arranged gonidia of about 50 to 55 μ. × 100.

PLATE 3

FIG. 15. An asexual coenobium of *Merrillosphaera carteri* var. *manilana* with five asexual daughters and three gonidia. The daughters are the foremost four and the left (distant) member of the hindmost four. The gonidia are about 85 μ in diameter. Each daughter contains eight gonidia that are about 12 μ in diameter. × 100.

16. A young asexual coenobium of the smaller form. It has ten gonidia. They are not typically arranged. Two nearest the forward pole are the smallest, or else the figure is upside down, in which case the forward group of four is midway between the equator and the forward pole. × 100.
17. An asexual coenobium with nine gonidia in the typical arrangement of two fours with an odd one occupying one of the places of a hypothetical third group of four. The small gonidia 35 μ, the others about 46 μ wide. × 100.
18. A mature asexual coenobium with eight female daughters arranged in two symmetrical groups of four. There are twenty-one oogonidia in the nearest daughter, and they are about 15 μ in diameter. × 100.
19. A young asexual coenobium with seven gonidia of 24 to 28 μ diameter. × 100.
20. A mature asexual coenobium of the smaller form. It contains eight daughters. The uppermost of these contains nine gonidia, the others eight. The gonidia measure from 18 to 25 μ. × 100.
21. An asexual coenobium of the smaller form. It has eight gonidia and about 1,600 somatic cells. × 100.
22. An asexual coenobium of the smaller form. It has seven gonidia of about 10 to 22 μ, and about five hundred somatic cells. × 100.
23. An anomalous coenobium containing thirty-five reproductive bodies of three kinds. Four are daughters, all asexual, in one of which eight gonidia can be counted. In the others only six or seven can be seen, though there may be one or two more in obscurity. Fourteen of the bodies are about 42 μ wide and are supposed to be gonidia, and seventeen are 26 to 32 μ wide and supposed to be oogonidia. × 100.

PLATE 4

FIG. 24. A mature female coenobium of *Merrillosphaera carteri* var. *manilana* with thirty-six oospores and two immature reproductive cells. × 100.

25. A Venetian turpentine preparation of one of the smaller form. It contains twelve symmetrically arranged daughters of which the hindmost four are smaller than the others. The front of the coenobium is turned a little away from the observer. × 100.

26. A Venetian turpentine preparation of one of the smaller form from the same source as the foregoing. Ten symmetrically arranged daughters include two that are smaller than the others and form a hinder pair. The front of the coenobium is turned slightly toward the observer. × 100.

27. A Venetian turpentine preparation of one of the smaller form from the same source as the foregoing. It presents a side view showing eight gonidia symmetrically arranged. The gonidia measure about 57 μ. × 100.

28. A Venetian turpentine preparation of one of the smaller form from the same source as the foregoing. It contains eight gonidia of about 35 to 40 μ diameter. The coenobium is turned about 43° away from the observer. × 100.

29. A portion of the same coenobium as that of fig. 24 showing two of the oospores and some of the somatic cells of the coenobium wall. In a direct view some of the spore walls appear more decidedly wavy than shown in this figure. × 400.

30. A Venetian turpentine preparation stained with Bismarck brown. A nearly front polar view of a coenobium with eight daughters that form two groups of four. The thickness of the layer of somatic cells is shown to be greater between the daughters and less over the daughters. × 100.

31. The same coenobium as shown in fig. 30, photographed after being rotated 90°. The poles had been flattened. Some of the boundaries of the gonidial capsules can be seen. × 100.

PLATE 5

FIG. 32. Rear polar view of a coenobium with ten gonidia arranged in two groups of four that are about 64 μ in diameter and a hinder pair that are about 53 μ in diameter. × 100.

33. An asexual coenobium with eight gonidia in two groups of four. An anomalous member of the forward four is smaller than the others, being only 28 μ wide, while the others are 46 to 60 μ. × 100.

34. A mature asexual coenobium of *Merrillosphaera carteri* var. *manilana* with ten asexual daughters, of which there is a hinder pair of smaller ones and two very symmetrical groups of four that are about equal. The front is turned about 24° away from the observer. There are probably eight gonidia or less in each daughter. × 100.

35. An asexual coenobium of the smaller form. The eight gonidia have all divided into 2, 4, 8, 16, or 32 cells. × 100.

36. An asexual coenobium of the smaller form. It contains twelve reproductive bodies. Two of the hindmost are gonidia that measure 54 μ and 54 by 57 μ. The others have divided into 2, 4, or 8 cells each and are in process of dividing again. × 100.

PLATE 6

FIG. 37. Side view of a coenobium with eight gonidia about 60 μ in diameter. × 100.

38. An asexual coenobium with eight gonidia of about 53 to 60 μ diameter. The gonidia are fairly symmetrically arranged, but the coenobium is turned about 45° away from the observer. × 100.

39. A mature asexual coenobium of *Merrillosphaera carteri* var. *manilana* with nine asexual daughters. They form a group of four just in advance of the middle, a group of three arranged like a quartet with one member absent just back of the middle, and a pair of smaller ones a little farther back. × 100.

40. A Venetian turpentine preparation. The same as shown in figs. 30 and 31. × 200.

41. A mature asexual coenobium with seven daughters that form a symmetrical group of four slightly in advance of the middle and a group of three arranged as if members of a group of four from which one is missing. In six of the daughters eight gonidia were counted. × 100.

PLATE 7. MERRILLOSPHAERA CARTERI VAR. TYPICA

42. A reproduction of Carter's first figure ('59, *pl. 1, fig. 1*) enlarged to make the magnification about × 100. A coenobium with eight daughters, each of which contains eight gonidia. An artificiality of the drawing has resulted in failure to show the symmetrical arrangement of the daughters and gonidia in groups of four. × about 100.

43. Carter's figure ('59, *pl. 1, fig. 1 a*) of a somatic cell, showing the rounded form of the protoplast and the absence of connecting filaments. Size not stated.

44. Carter's figure ('59, *pl. 1, fig. 4*) of a gonidium about 85 μ in diameter and nearly ready to divide. × about 400.

45. Carter's figure ('59, *pl. 1, fig. 3*) of a coenobium with eight nearly mature gonidia, one of which is shown more magnified in fig. 44. The real arrangement of the gonidia is probably not shown because of an artificiality introduced into the drawing to prevent any overlapping of gonidia and at the same time leave the front of the coenobium free from reproductive cells. × about 100.

PLATE 8. MERRILLOSPHAERA CARTERI VAR. TYPICA

46. Carter's figure ('59, *pl. 1, fig. 7*) of a female coenobium. × about 100.

47. Carter's figure ('59, *pl. 1, fig. 7 a*) of an oospore after fertilization. × about 650.

48. Carter's figure ('59, *pl. 1, fig. 8 a*) of a male coenobium. × about 100.

49. Carter's figures ('59, *pl. 1, fig. 10 a* and *b*) of antheridia. × about 650.

50. Carter's figure ('59, *pl. 1, fig. 8 b*) of spermatozoids. × about 1,000.

TEXT FIGURE

FIG. 1. Protoplasts and membranes of the body cells of *Merrillosphaera tertia* (Meyer) comb. nov. After Meyer. *a*, tangential section at about the level of the middle of the outer half of the cell; *b*, similar section at about the middle of the inner half of the cell; *c*, diagrammatic radial section through body cells.

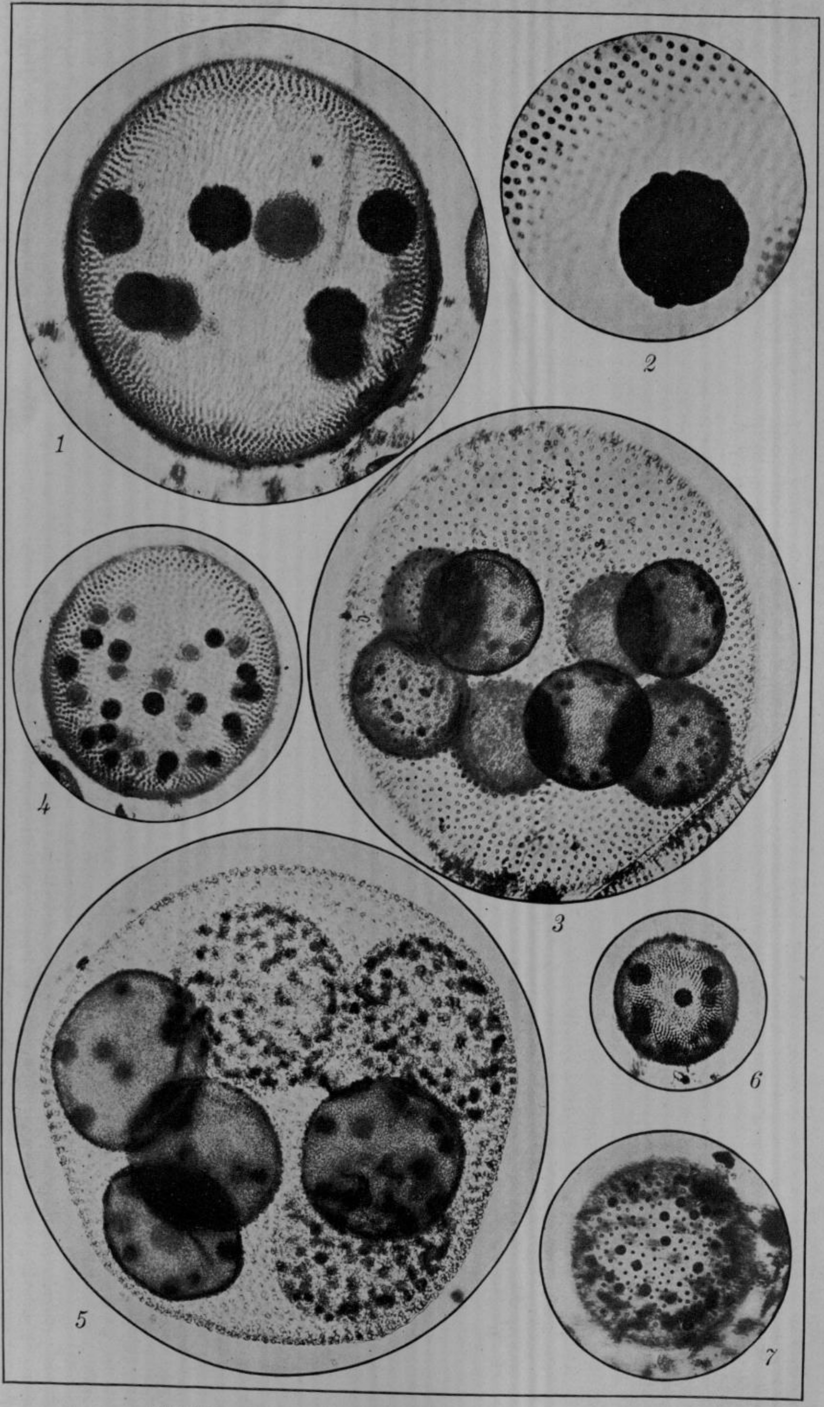


PLATE 1. MERRILLOSPHAERA CARTERI (STEIN) SHAW.

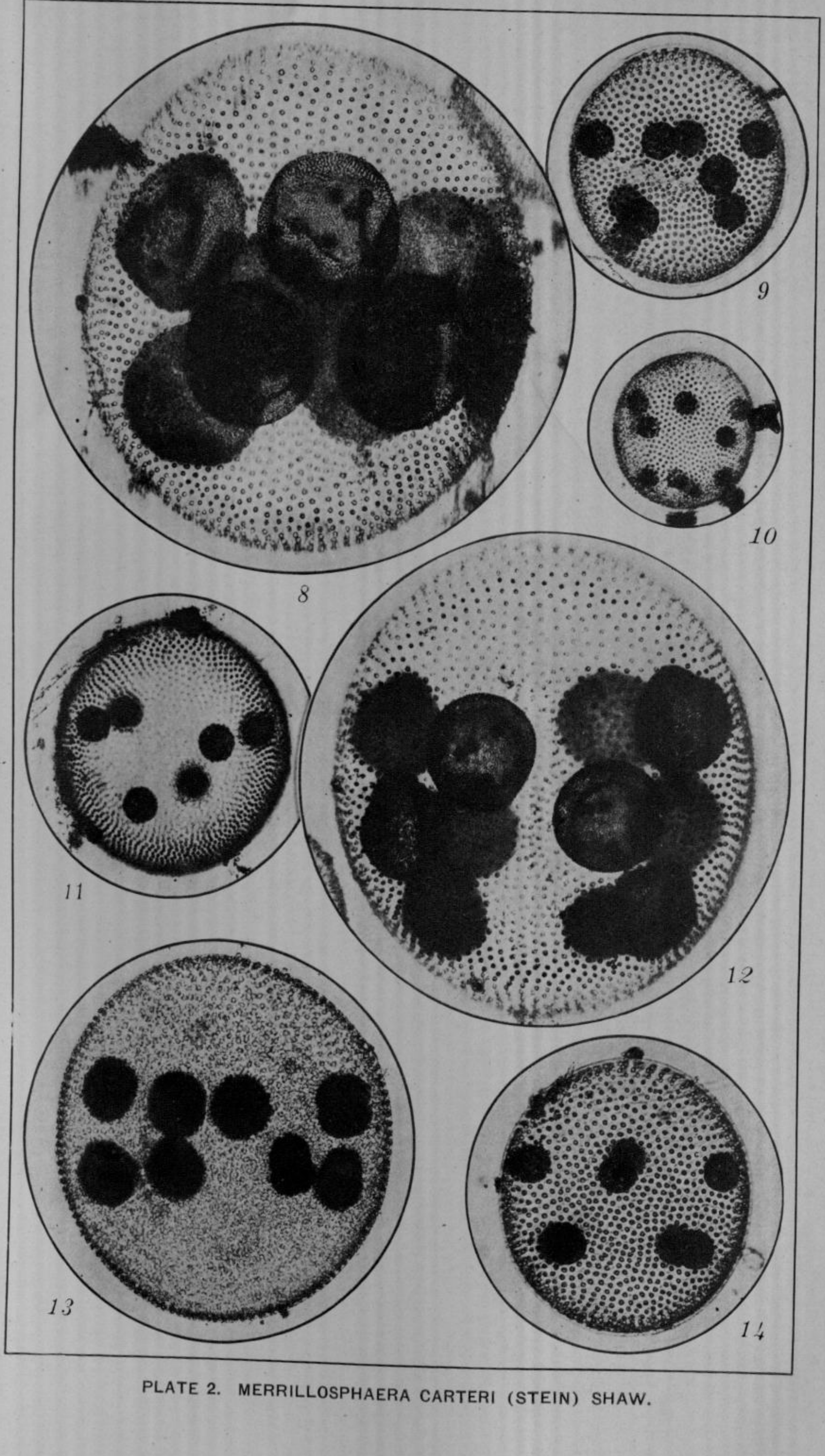


PLATE 2. MERRILLOSPHAERA CARTERI (STEIN) SHAW.

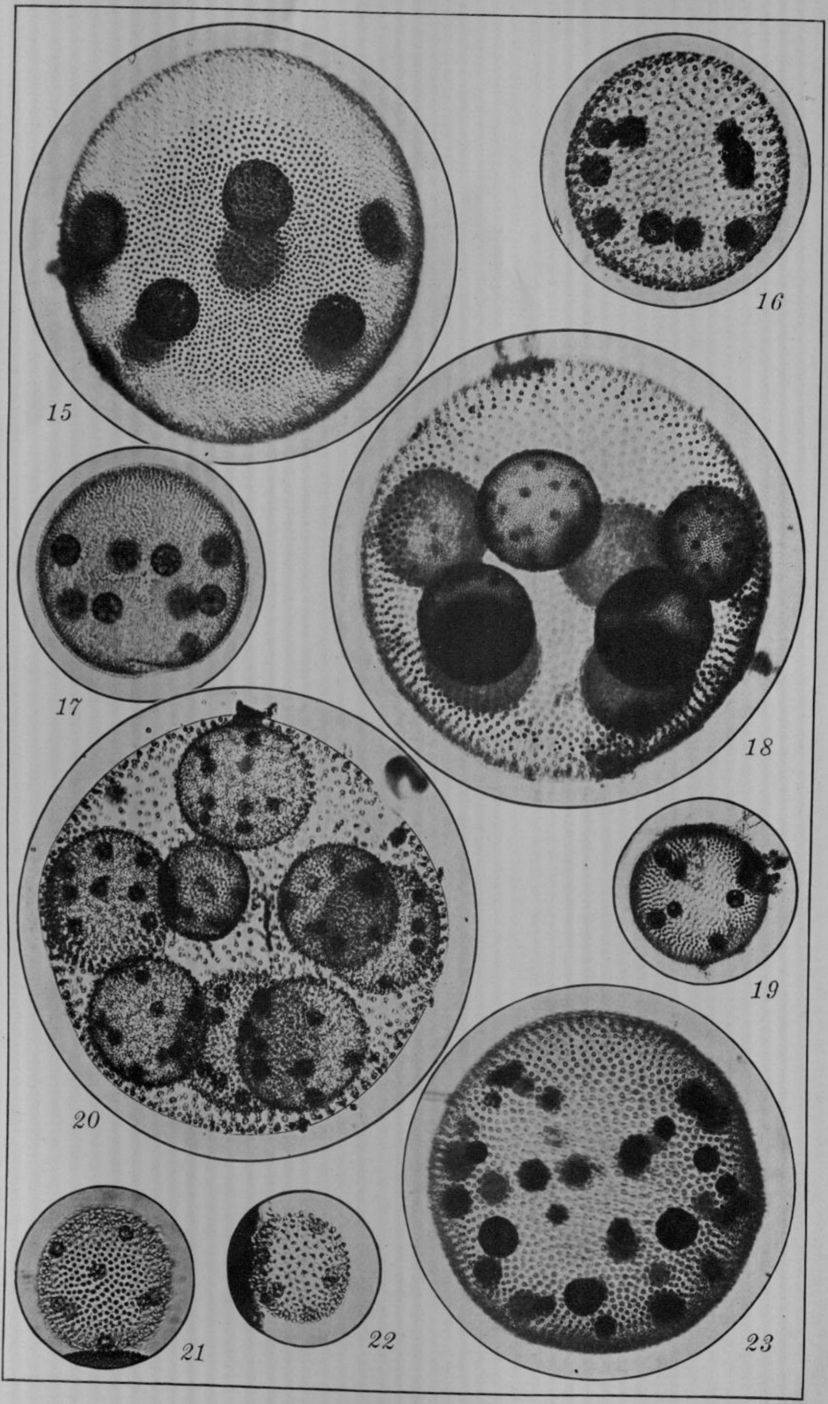


PLATE 3. MERRILLOSPHAERA CARTERI (STEIN) SHAW.

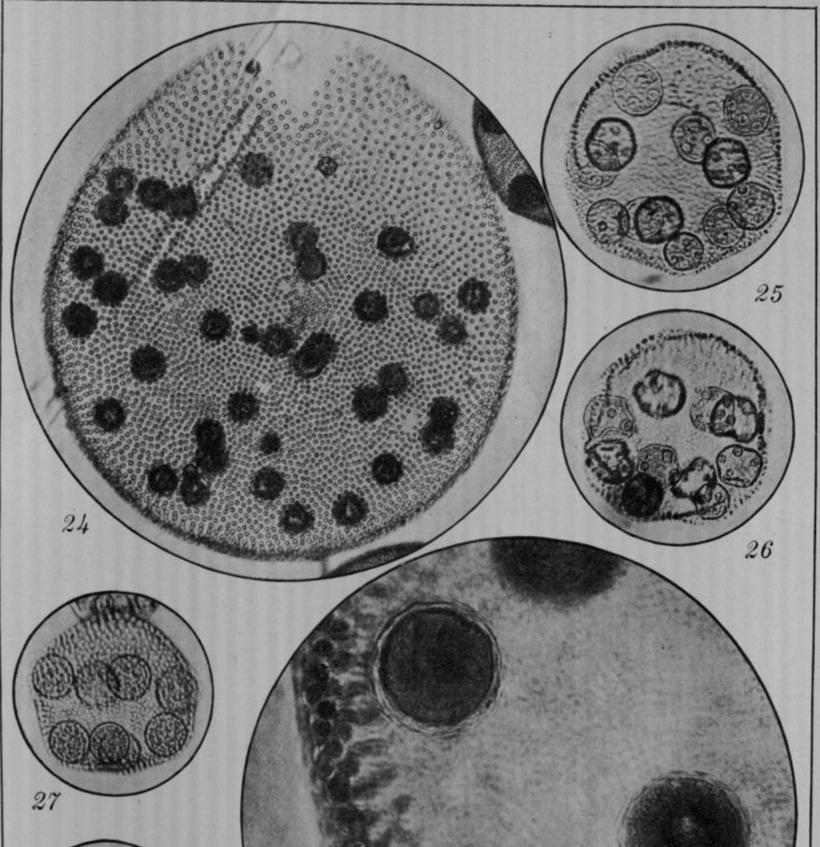


PLATE 4. MERRILLOSPHAERA CARTERI (STEIN) SHAW.

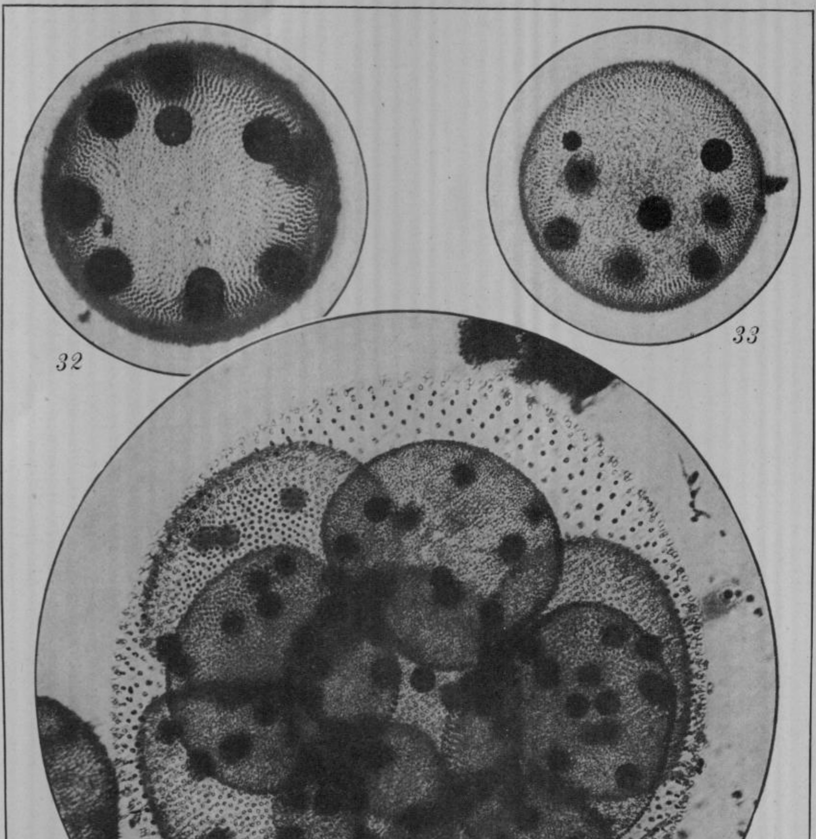


PLATE 5. MERRILLOSPHAERA CARTERI (STEIN) SHAW.

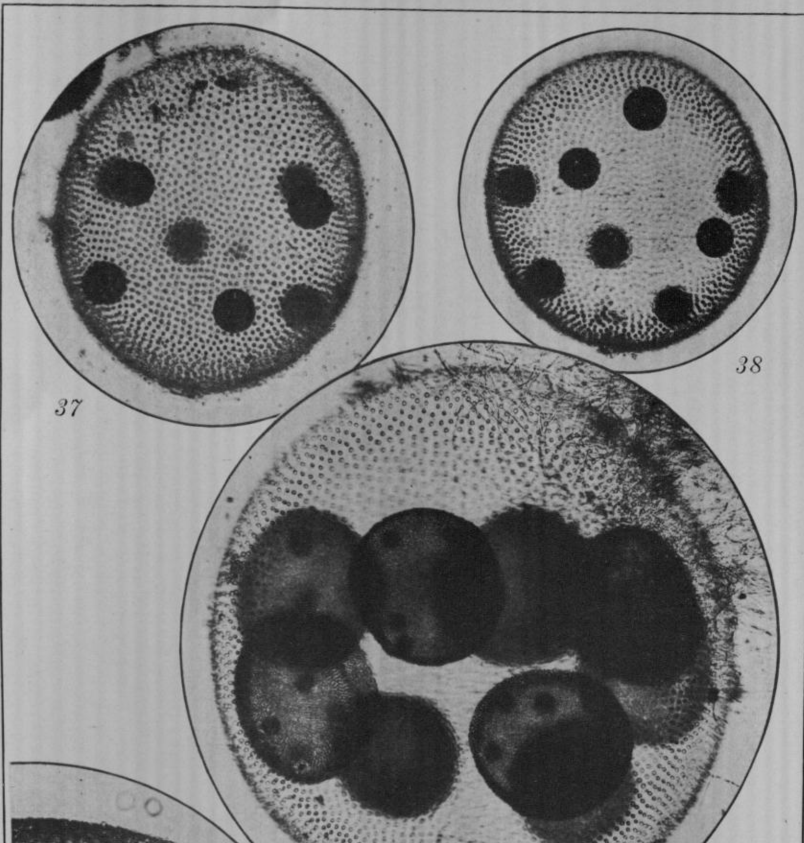
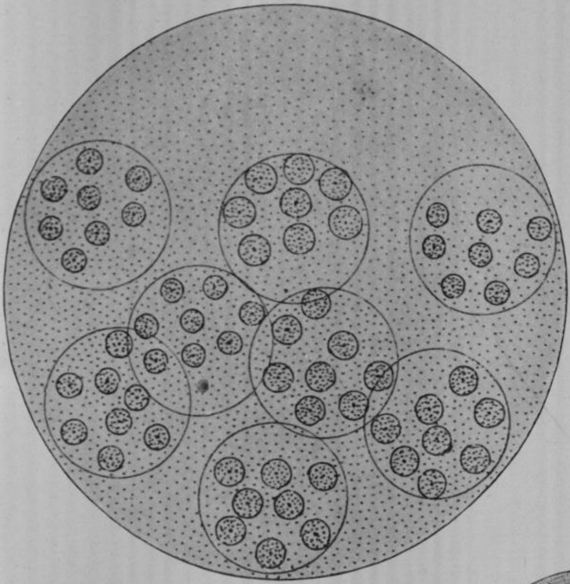


PLATE 6. MERRILLOSPHAERA CARTERI (STEIN) SHAW.



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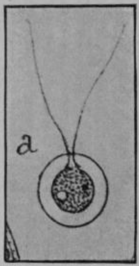

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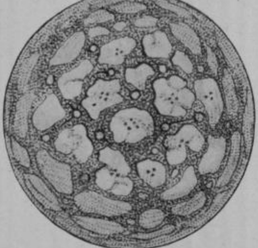

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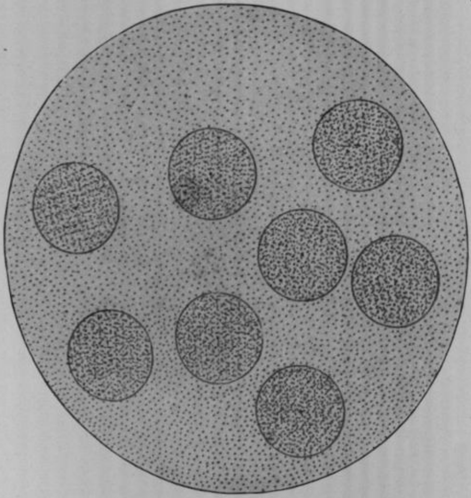

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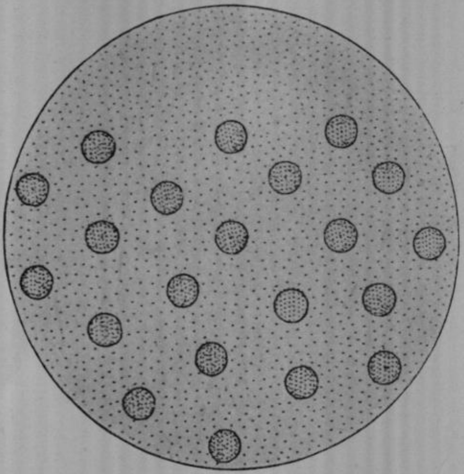
PLATE 7. MERRILLOSPHAERA CARTERI (STEIN) SHAW.



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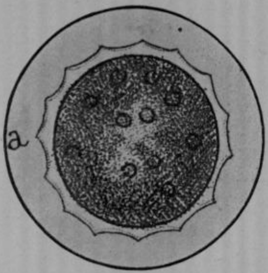

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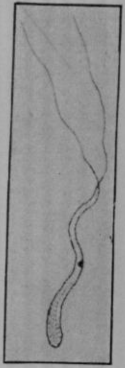

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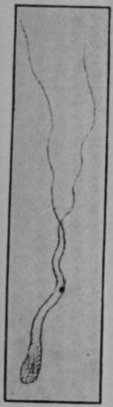

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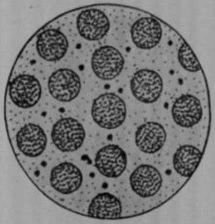

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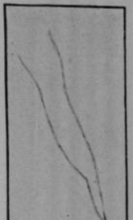

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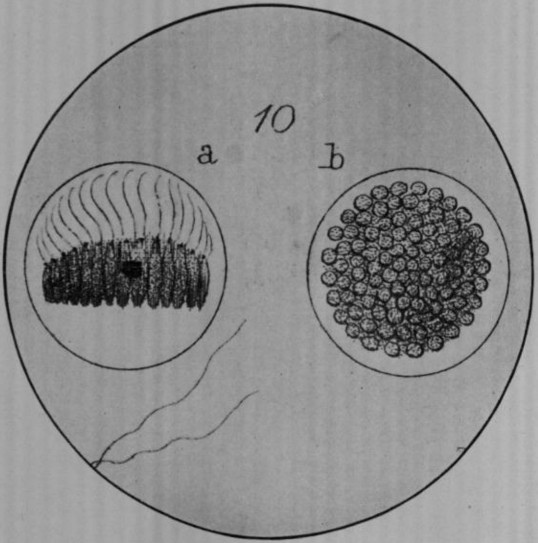

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PLATE 8. MERRILLOSPHAERA CARTERI (STEIN) SHAW.

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